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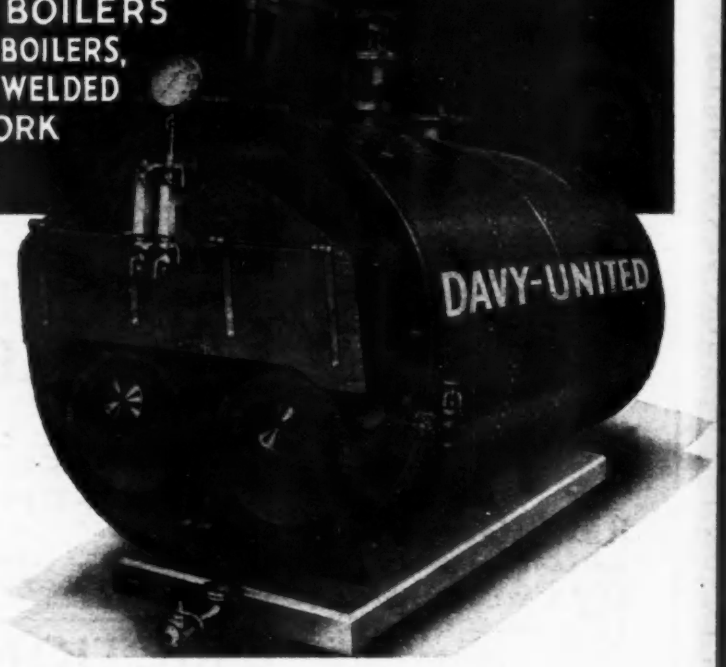

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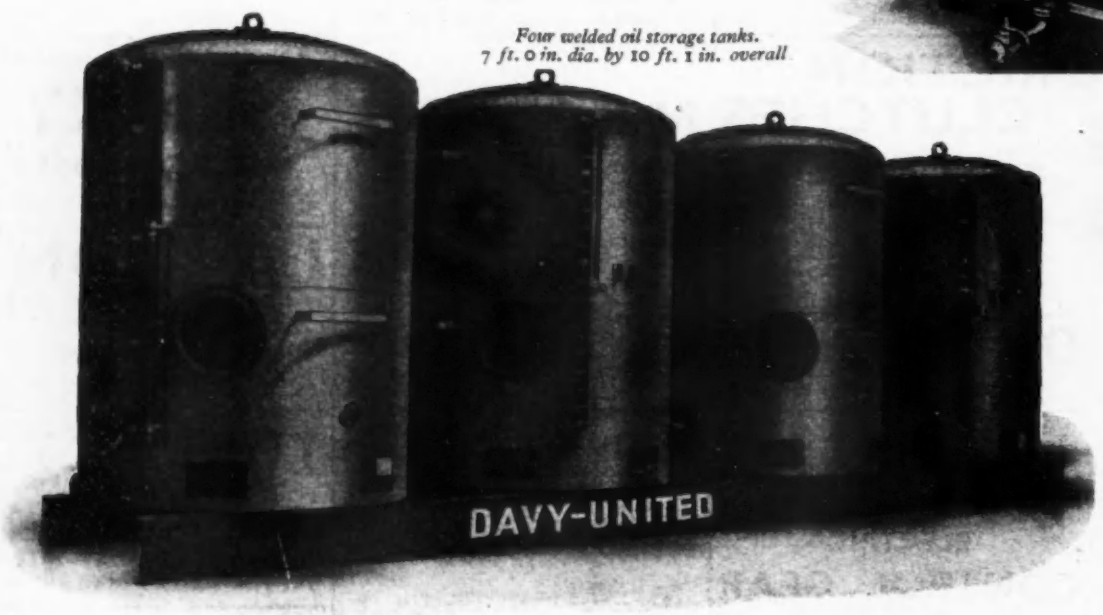

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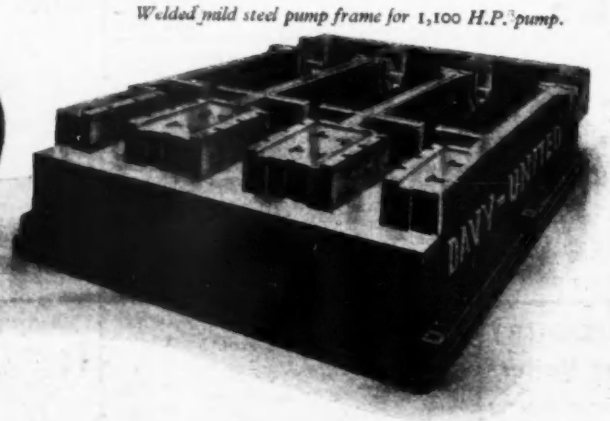

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ALUMINIUM-BRONZE GRAVITY DIE CASTING.

By DR. ARTHUR STREET.

IT is just over fifty years ago since aluminium-bronze was first mentioned in the columns of ENGINEERING. The reference occurs in the report of a lecture by a Mr. W. C. Wallace,* entitled "The Material Best Suited for Propeller Blades." After discussing many alloys, he says, "Aluminium bronze and [aluminium] brass have been little used for propellers of any size but they must take a prominent place if their advocates can make good their claims for this material." This remark indicates that the author was inclined to be somewhat dubious regarding the value of the alloys. Mr. Wallace then gives some physical properties; for instance, he states that for copper plus 10 per cent. of "aluminium and silicon," the tensile strength was 30·4 tons with elongation 3·2 per cent., presumably on 2 in. (The former figure compares well with results obtained to-day but such a ductility figure would be counted dangerously low; elongations ten or more times Mr. Wallace's figure are regularly achieved.) While investigating the "ancient history" of the material it may be interesting to record that the rather slighting remarks quoted above did not long go unchallenged, for, about a month later, May 18, 1888, Mr. Eugene H. Cowles* stated that the tensile strength of aluminium-bronze was anything from 25 per cent. to 90 per cent. greater than the figures quoted by Mr. Wallace. Even this advocate, however, only credited the alloy with an elongation of about 5 per cent. Many developments have occurred since those days and now elongation figures are expected to be anything from 20 per cent. to 40 per cent. on 2 in., but it is still true that, like the first author referred to, there are many engineers who have not appreciated, and taken advantage of, the properties of aluminium-bronze.

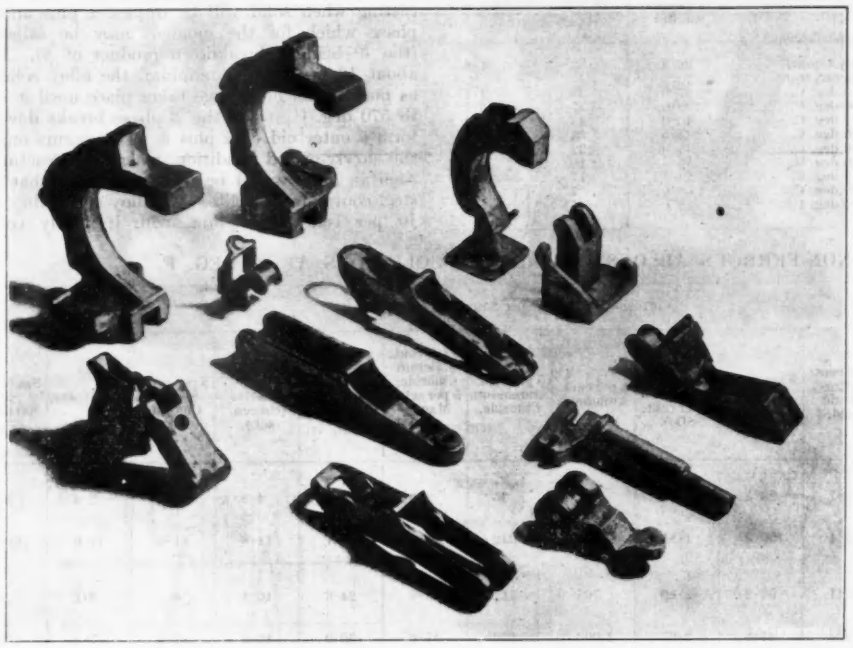


FIG. 1. CASTINGS FOR UNDERGROUND RAILWAY EQUIPMENT.

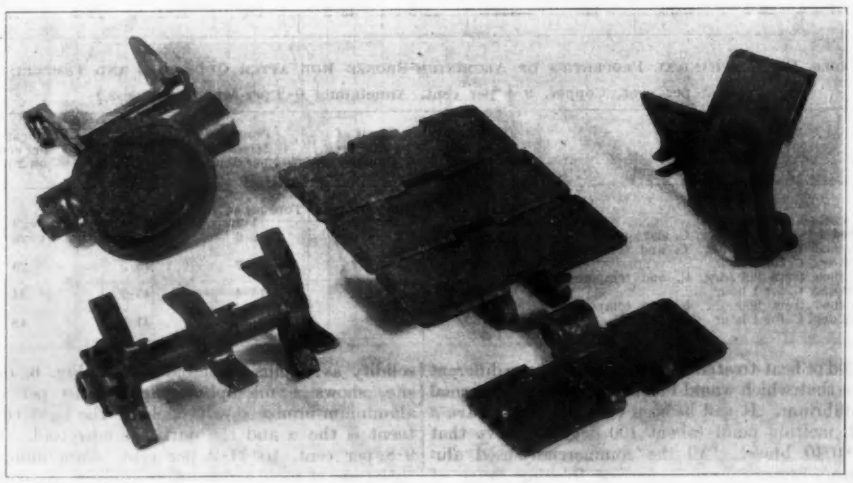


FIG. 2. CASTINGS FOR AUTOMATIC MACHINES.

Of course, most metals and alloys, ranging from nickel to the zinc-base die-casting alloys, passed through an initial period of neglect before their true worth was realised, but aluminium-bronze has been a "Cinderella" longer than most alloys, and certainly, in this country, we still do not use it as widely as it deserves. The reason why aluminium-bronze was so long in securing the attention it merits was because the manufacture of sand castings in this material presented many individual problems which were not overcome until about twenty years ago. Early founders attempted to cast aluminium-bronze using exactly the same methods as were being applied to 60/40 brass, but the results were disappointing. Furthermore, owing to its metallurgical constitution, aluminium-bronze, when in the slowly-cooled condition brought about by sand casting, does not exhibit its optimum physical properties. The position may be appreciated by imagining that steel had only just been invented and that a founder, accustomed to making brass castings, had attempted to sand-cast steel without making any change of procedure. If the whole potentialities of steel were to depend on the results obtained, the material would not show up very favourably. The position of aluminium-bronze is exactly similar.

The following four important factors have led to the commercial development of the aluminium-bronze alloys. In the first place, P. G. H. Durville* showed, in 1913, that in order to avoid occluded oxide it was necessary to cast aluminium-bronze in a non-turbulent manner. Although usually it is only large ingots and castings that are made by the Durville process, the improvements in the production of small castings can be traced to his work. Secondly, commencing with the monumental research of Carpenter and Edwards,† in 1907, followed by work by Greenwood‡ in 1918 and by Stockdale§ in 1922, the equilibrium diagram of the copper-rich copper-aluminium alloys was established. Since then, only clarifications and minor corrections have been put forward, such as those by Bradley and Jones,‖ and Smith and Lindlief.¶ The constitution of these alloys was shown to be such that aluminium-bronze, particularly that with 10 per cent. aluminium, should be susceptible to improvement by heat treatment. Indeed, it has been found that aluminium-bronze is almost as interesting as steel as regards the scope of heat treatment. The third factor of importance is that the addition of aluminium to copper results in a considerable improvement in the resistance to corrosion and many of the uses of aluminium-bronze are due to this property. Table I, page 160, gives a comparison of the corrosion-resistance properties of aluminium-bronze with those of other non-ferrous alloys, and it will be seen how well it compares. In particular, the corrosion resistance in sea water will be noted and this explains why aluminium-bronze is widely used for marine fittings. Furthermore, the corrosion-fatigue properties of this alloy are outstandingly high for a copper-base material. Thus, D. J. McAdam** reports that the fatigue limits (100 million reversals) of aluminium-bronze when tested in air and water, were, respectively, $\pm$ 14·5 tons and $\pm$ 10·5 tons per square inch. This means that, in this respect, the aluminium-bronzes are definitely superior to normal straight carbon steels and they compare favourably with high-grade stainless steels as regards corrosion-fatigue properties. Lastly, fabrication methods such as hot and cold rolling, forging, centrifugal casting and die-casting have been applied to aluminium bronze and it has been found that, by the use of these methods, considerably improved physical properties can be attained as compared with the alloy in the foundry-cast condition.

Although this article deals with aluminium-bronze in a general way, the various remarks have been made with the gravity die-casting process in mind. Figs. 1, 2 and 3, annexed, and on page 161, illustrate gravity die-castings in this material. Fig. 1 shows a number of die-castings employed in the control gear of new Underground trains which have recently been put into commission in London. The pair of large die-castings on the extreme left weigh over 4 lb. each, while the casting near the centre, immediately above the lowest specimen, is the well-known "dead man's handle." Fig. 2 shows aluminium-bronze die-castings which are used in connection with food products; the casting at the bottom left-hand corner plays an important part in the working of an automatic machine retailing a

* See ENGINEERING, vol. 45, page 356 (1888).

* See ENGINEERING, vol. 45, page 492 (1888).

* See *Metal Industry* (American), vol. 18, page 118 (1920).

† See Eighth Report of Alloys Research Committee, *Proc. Inst. Mech. E.*, 1907, page 57.

‡ See *Jl. Inst. Met.*, vol. 19, page 55 (1918), and ENGINEERING, vol. 105, page 277, *et seq.* (1918).

§ See *Jl. Inst. Met.*, vol. 28, page 273 (1922).

‖ See *Jl. Inst. Met.*, vol. 51, page 131 (1933).

¶ See *Amer. Inst. Min. and Met. Engrs. Tech. Pub.* No. 493, page 139 (1933).

** See *Proc. Int. Congress for Testing Materials.* Amsterdam, 1927, page 305.

certain form of sweetmeat, and the casting at the top left-hand corner is the main part of the apparatus used for serving spirits. Fig. 3, opposite, shows a miscellaneous group of die-castings, and it will be noted that forms of considerable complexity can be produced.

An excellent exposition of the properties, constitution, heat treatment and die-casting, and other methods of fabrication of the material is given in the book *Aluminium Bronze*, recently issued by the Copper Development Association.* The author is indebted to the Association for permission to reproduce some of the information included in the present article.

Properties of Aluminium-Bronze.—The 10 per cent. aluminium-bronze has a strength approaching that of a medium-carbon steel, a fatigue resistance definitely high for a non-ferrous metal alloy, considerable strength at high temperatures and a resistance to corrosion at least as good as that of an 80/20 cupro-nickel. In addition, it has an attractive "10-carat gold" appearance and is reasonably cheap. The alloys which are commercially important consist of copper containing aluminium up to 12 per cent., but, so far as castings and die-castings are concerned, it is the alloys containing 8 per cent. to 11 per cent. aluminium which are chiefly used. The addition of aluminium to copper has a striking influence on the physical properties. Fig. 4, on the opposite page, shows the effect of aluminium on the alloy in its sand-cast and chill-cast forms. The dotted curves refer to chill-cast and the full-line curves to sand-cast alloys. The elongation figures are given in per cent. on 2 in. The combination of strength and ductility at about 10 per cent. aluminium will be noted, but it will be observed that further increases in aluminium cause a rapid reduction in the elongation figure. With over 12 per cent. aluminium, the alloys become practically useless and with about 16 per cent., a composition is obtained which is so brittle that a specimen of it will break if dropped, and the material may easily be crushed into a powder.

Table II.—*Effect of Quenching on Brinell-Hardness Numbers of Aluminium-Bronze (Matsuda).*

Treatment.	9·77 Per cent. Aluminium.	10·25 Per cent. Aluminium.	10·87 Per cent. Aluminium.
Slowly Cooled ..	120	147	175
Quenched from—			
550 deg. C. ..	120	145	173
600 deg. C. ..	107	128	142
650 deg. C. ..	110	136	160
700 deg. C. ..	119	158	185
750 deg. C. ..	140	206	217
800 deg. C. ..	145	227	218
850 deg. C. ..	153	235	218
900 deg. C. ..	155	243	220
950 deg. C. ..	160	248	218
1,000 deg. C. ..	165	252	221

Constitution of Aluminium-Bronze.—Fig. 5, opposite, illustrates the equilibrium diagram of the alloys with up to 15 per cent. aluminium and is based on the work of Stockdale.* It is important to remember that the diagram represents equilibrium conditions arrived at by very slow cooling, and, as will be stressed later, alloys which are rapidly cooled or heat-treated have a microstructure different from that which would be obtained when in thermal equilibrium. It will be seen that the alloys have a high melting point (about 100 deg. C. above that of 60/40 brass). All the commercially-used aluminium-bronzes have a narrow freezing range of only a few degrees and this partly accounts for some of the difficulties which beset early founders. As the alloy solidifies without an appreciable plastic range, the whole casting freezes rapidly *en masse*, so that shrinkage appears as a number of small cavities distributed through the casting. This is, of course, one of the points concerning which modern founders have to exercise care, the difficulty being overcome by the provision of a generous number of risers. Referring to the equilibrium diagram, Fig. 5, it will be seen that alloys with from 0 to 7·4 per cent. aluminium form a single α solid solution on freezing. These are the cold-working alloys, and, as is usual with most α solid solutions, they have high ductility (see Fig. 4). With aluminium from 7·4 per cent. to 8·9 per cent. the alloys, immediately after solidification, consist of two phases, α and β. It will be noticed, however, that the solubilities vary with temperature. Thus, for example, at 1,000 deg. C., the 8 per cent. alloy consists of α plus β, but if it is slowly cooled, the β phase becomes dissolved so that by the time it has reached 900 deg. C., the alloy consists entirely of α solid solution.

Table III.—*Effect of Quenching from Various Temperatures on Tensile Strength, Elongation and Notched-Bar Impact Strength of Aluminium-Bronze containing 9·77 per cent. Aluminium.*

Treatment.	Tensile Strength. (Tons per sq. in.)	Elongation. (Per cent. on 2 in.)	Izod Value. (Kg. m.)
Slowly Cooled ..	36·5	33	1·6
Quenched from—			
550 deg. C. ..	37·0	33	1·7
600 deg. C. ..	39·0	47	5·3
650 deg. C. ..	40·0	43	5·1
700 deg. C. ..	41·5	38	4·8
750 deg. C. ..	45·0	32	4·1
800 deg. C. ..	50·5	19	3·6
850 deg. C. ..	54·5	17	3·2
900 deg. C. ..	58·0	7	4·3
950 deg. C. ..	58·0	5	5·2

On account of the change of solubility, rapid cooling or heat treatment will permit the suppression of the normal phase changes. Thus, if an alloy with 9 per cent. aluminium is very slowly cooled, it will be entirely in the α condition by the time it has reached room temperature, but if it is rapidly cooled, equilibrium will not be attained. The casting when solid will be duplex-α plus another phase which for the moment may be called β^1 (the β^1 being a breakdown product of β). With about 12 per cent. aluminium, the alloy solidifies as pure β and no change takes place until it cools to 570 deg. C., when the β phase breaks down to form a eutectoid of α plus δ. This occurs only in the slowly-cooled condition, when the structure of such an alloy would be quite similar to that of a steel containing pearlite. An alloy containing, say, 10 per cent. aluminium, will, if slowly cooled, solidify as α plus eutectoid; thus, Fig. 6, opposite, shows a microphotograph of 10 per cent. aluminium-bronze slowly cooled; the light constituent is the α and the dark the eutectoid. With 9·8 per cent. to 11·9 per cent. aluminium, the structure, at room-temperature equilibrium, consists of α plus eutectoid, and, from 11·9 per cent. to 16·9 per cent., the structure is δ plus eutectoid. The δ separates out along the grain boundaries and is dispersed through the grains; such a separation renders the alloy brittle and accounts for the fact that compositions containing more than 11 per cent. of aluminium are of little value. Rapid cooling prevents the complete formation of the pearlitic eutectoid structure, and, by quenching, a state of affairs similar to that in rapidly-cooled steel arises. Just as no amount of rapid cooling can preserve austenite in a straight carbon steel, so in aluminium-bronze rapid cooling cannot prevent the atomic structure of the β from changing at 570 deg. C., but rapid cooling does prevent the pearlitic eutectoid from forming and a transition stage akin to martensite or troostite is produced. This is what has already been referred to as β^1.

If a 10 per cent. alloy is rapidly cooled from about 750 deg. C. (*i.e.*, from a temperature at which it consists of α plus β) and examined under the

TABLE I.—CORROSION OF NON-FERROUS ALLOYS IN AERATED SOLUTIONS AT 60 DEG. F.

Percentage Composition of Alloy.	Corrosion Rate (Mg. per Square Dm. per Day.)												
	5 per cent. Nitric Acid.	5 per cent. ulphuric Acid.	5 per cent. Hydrochloric Acid.	5 per cent. Acetic Acid.	Sulphurous Acid (6 per cent. SO_2).	5 per cent. Ammonia.	5 per cent. Ammonium Chloride.	5 per cent. Calcium Chloride, 5 per cent. Magnesium Chloride.	5 per cent. Sodium Hydroxide.	Calcium Hypochlorite (concen. sol.).	5 per cent. Sodium Chloride	Sea Water.	Sea Water at 200 deg. F.
Aluminium-Bronze— 85·4 Cu, 10·6 Al, 3·1 Fe, 0·8 Mn ..	2,130	34·5	687	29·5	0·83	843	36	2·9	15·2	4·8	9·4	2·4	2·5
Manganese-Bronze— 56·5 Cu, 1·1 Fe, 0·9 Mn, 0·4 Pb, 0·3 Al, 40·8 Zn (by diff.)	5,772	132	3,084	130·5	1·81	940	342	11·5	43·7	11·8	11·9	11·9	20·0
Manganese-Bronze— 65·1 Cu, 1·6 Fe, 0·4 Mn, 0·2 Pb, 3·0 Al, 0·9 Sn, 28·8 Zn (by diff.) ..	3,547	112	711	53·2	2·89	765	112	8·6	24·3	10·1	6·1	3·2	2·1
Brass— 66·8 Cu, 0·2 Fe, 0·9 Sn, 3·8 Pb, 28·3 Zn (by diff.)	3,423	102	765	41·8	2·67	1,098	138	17·6	30·9	10·5	11·2	7·0	9·1
Phosphor-Bronze— 88·0 Cu, 11·3 Sn, 0·5 Pb	1,246	98	801	13·4	1·49	210	150	7·9	30·9	4·3	11·0	12·0	6·4
Gun-Metal— 85·0 Cu, 9·1 Sn, 3·6 Pb, 2·3 Zn ..	1,033	144	847	20·5	0·75	126	154	12·5	43·2	1·0	17·1	12·3	7·5

Table IV.—Mechanical Properties of Aluminium-Bronze Rod after Quenching and Tempering. (90·3 per cent. Copper, 9·4 per cent. Aluminium, 0·2 per cent. Manganese.)

Condition.	Diamond-Pyramid Hardness.	Limit of Proportionality.	Proof Stress (0·1 per cent.).	Tensile Strength	Elongation. Per cent. on 2 in.
		Tons per sq. in.	Tons per sq. in.	Tons per sq. in.	
Hot worked and drawn	178	7·7	15·4	33·4	28
Heated 1 hour at 900 deg. C. and quenched ..	187	4·9	12·6	48·6	29
Quenched from 900 deg. C. and tempered at 400 deg. C. for 1 hour	185	3·7	13·7	48·5	29
Quenched from 900 deg. C. and tempered at 600 deg. C. for 1 hour	168	7·1	15·4	45·2	34
Quenched from 900 deg. C. and tempered at 650 deg. C. for 1 hour	150	9·8	14·4	41·8	48

* See Copper Development Association, Publication No. 31.

* *Loc. cit.*

ALUMINIUM-BRONZE GRAVITY DIE CASTINGS.

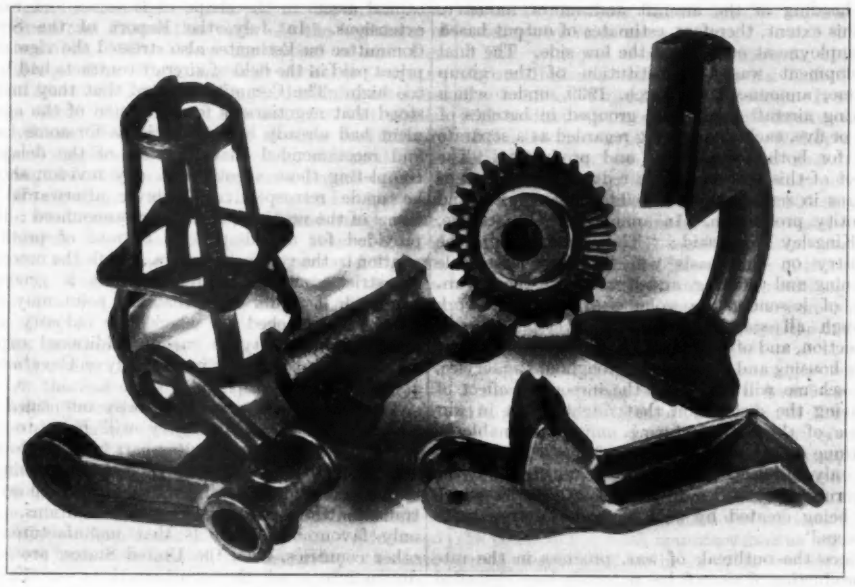
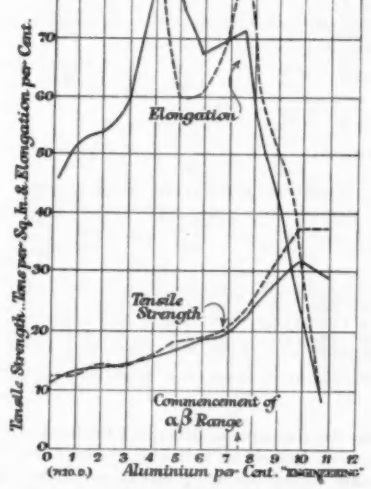


FIG. 3. MISCELLANEOUS CASTINGS.



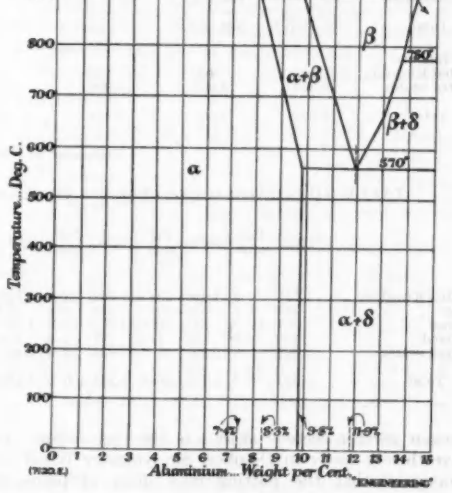


FIG. 6. 10 PER CENT. ALUMINIUM-BRONZE. SLOWLY COOLED. × 110.

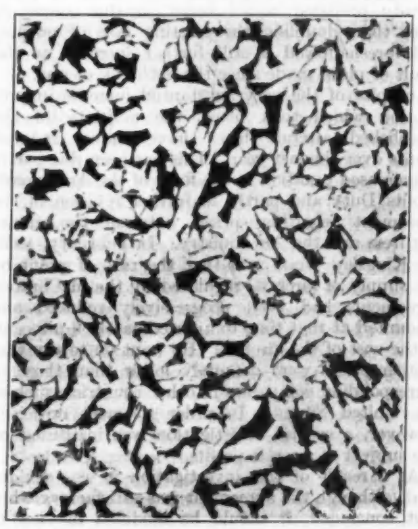


FIG. 7. 10 PER CENT. ALUMINIUM-BRONZE. DIE CAST. × 110.

microscope at low magnification, Fig. 7, it appears as though there are two phases present—a dark background and a lighter needle-like constituent. The latter is the α phase and the former the β^1 (it should be remarked in passing that the β^1 is also referred to as α^1). So far as the user of aluminium-bronze is concerned, these effects are valuable, for by producing the β^1 constituent, a considerable improvement in strength and hardness is attained. In particular these phenomena bring about excellent physical properties in die-cast aluminium-bronze; the chill-casting effect causes the β^1 structure to be formed, with consequent increase in tensile strength and hardness. A die-cast 10 per cent. aluminium-bronze will have a strength up to 30 per cent. greater than that of the same alloy sand cast. Table II. opposite, shows the effect of quenching, from various temperatures, on the hardness of aluminium bronzes. By comparing this table with the equilibrium diagram, Fig. 5, it will be seen that, as the temperature increases, more and more β is formed at the expense of the α. The temperature at which all the alloy has been changed to β represents the quenching temperature which gives maximum hardness. Table III, opposite, shows the effect of quenching on the tensile strength, elongation and impact strength of an alloy containing 9·77 per cent. aluminium (similar to that which is widely die-cast). Just as rapid cooling improves the tensile properties, so does heat-treatment permit the user to select what properties he requires. The usual treatment consists of heating the metal well into the $\alpha\,\beta$ range, quenching it to form the "martensitic" structure and then tempering it to lower the hardness and increase the ductility. The alloys containing less than 10 per cent. aluminium are water quenched from about 850 deg. C. and tempered to 400 deg. to 625 deg. C. As in steels, the higher the temperature of tempering, the lower the hardness and the higher the ductility. Referring to the equilibrium diagram, it will be seen that, in the case of alloys containing more than 10 per cent. of aluminium, the quenching temperature should be reduced.

Table IV shows the effect of increasing tempering temperature on the properties of an aluminium-bronze which has been quenched from 900 deg. C. It will be seen how the hardness and strength are somewhat reduced, but the ductility increased, by raising the tempering temperature. Softening by heat-treatment is also possible, for if the alloy is heated just into the $\alpha\,\beta$ range and then slowly cooled past 570 deg. C., the "pearlitic" structure is formed. The writer recollects a case in which some aluminium-bronze die-castings were required to be turned and threaded at high speed and their hardness was such that the wear on the cutting tools was considerable. A softening treatment was evolved whereby the castings were heated to about 700 deg. C. (at which temperature the structure would be α plus β) held at that temperature for 1½ hours to 2 hours, slowly cooled down to about 400 deg. C., and then rapidly cooled in air. This produced a structure possessing excellent machinability. Great care has to be taken in any procedure which involves the slow cooling of aluminium-bronze from a high temperature. If the casting has been held in the β range and slowly cooled, a coarse eutectoid structure having low ductility develops. This was one of the difficulties which troubled early users of aluminium-bronze and is referred to as "self-annealing."

(*To be continued.*)

BRITISH STANDARD GLOSSARY OF TERMS USED IN RADIO DIRECTION FINDING.—The British Standards Institution, 28, Victoria-street, London, S.W.1, has recently issued an addendum to the British Standard Glossary of Terms used in Electrical Engineering (No. 205-1936). This addendum takes the form of a section dealing with the terms and definitions used in radio direction finding. These were prepared by the Direction-Finding Committee of the Radio Research Board and are published as a British Standard with the approval of the appropriate British Standard Committees and at the request of the Department of Scientific and Industrial Research. The addendum will be included in the body of the Glossary when that publication is revised. In the meantime, it can be obtained from the Institution at the price of 1*s.* 2*d.*, post free.

THE ENGINEERING OUTLOOK.

IV.—AIRCRAFT.

THROUGHOUT 1939 the production of aircraft was again limited only by productive capacity and the rate at which skilled labour could be made available. Separate statistics for employment in the aircraft industry are not available, but attention has already been drawn in a previous article to the sharp increase in employment in the production of motor vehicles, cycles and aircraft as a whole. Between 1935 and 1939, the number in employment in this group of industries rose from 285,830 to 459,170. In the former year the number employed in aircraft construction was approximately 35,000, leaving 250,800 for employment in the production of motor vehicles and cycles. Between 1935 and 1939 the production of motor vehicles increased by rather over 15 per cent., so that, making allowance for an increase in the output per man employed, employment in this industry may well have amounted to about 275,000 in 1939, leaving about 185,000 for employment in the aircraft industry. Employment thus increased more than five-fold over the period considered. In addition, there has been undoubtedly quite a substantial increase in the productivity of labour in the aircraft industry, since the new factories have been built on a larger scale than those existing in 1935, and every effort has been made to ensure the maximum efficiency. Since the output of complete aircraft in 1935 was about 150 per month, this confirms that production by the middle of 1939 must already have passed the figure of 1,000 per month.

TABLE I.—*United Kingdom Exports of Aircraft.*

Year.	Complete Machines.		Engines.		Total Exports (Machines, Engines and Parts).
	No.	Value, £000.	No.	Value, £000.	Value, £000.
1930 ..	317	601	552	539	2,050
1931 ..	304	779	362	413	1,860
1932 ..	300	641	451	467	1,741
1933 ..	234	475	409	448	1,466
1934 ..	298	747	478	592	1,922
1935 ..	453	1,215	652	696	2,726
1936 ..	448	1,285	625	741	2,924
1937 ..	506	1,911	588	633	3,676
1938 ..	506	2,462	862	1,173	5,407
1939 Jan.-Aug.	—	—	—	—	4,308

The estimated expenditure on airframes and aero engines, as shown in the Air Estimates, increased tenfold between 1935-36 and 1939-40, from 9,621,000*l.* in the former year to 93,640,000*l.* in the latter, without including, for 1939-40, the increases which have been made as a result of the outbreak of war. Four distinct stages can be traced in this remarkable expansion of output. In the first place, manufacturers were encouraged to extend their existing factories under guarantee that the Government would meet standing charges if the demand, on the completion of rearmament, should prove insufficient to keep the plant fully occupied, and if the firm in question had been unable to write off the capital cost of the extensions. This was followed by the "shadow factory" scheme, under which additional plants were erected at Government expense, to be managed by various firms in the motor and aircraft industries on Government behalf. That very considerable progress was made in this direction during the past year is shown by the fact that estimated Government expenditure on shadow factories and extensions to contractors' works increased from 4,000,000*l.* in 1937-38 to 5,250,000*l.* in 1938-39 and 16,250,000*l.* in 1939-40. These figures do not include extensions financed by the companies themselves, which also must have been considerable, judging from the number of firms which have recently been compelled to raise additional capital with the object of extending their capacity. In addition, of course, many extensions have been financed out of earnings.

Thirdly, there was the big expansion of the sub-contracting system, announced in October, 1938, which was described in this series last year. One point in connection with this system is that so far as sub-contracting firms are not engaged exclusively on aircraft production, their employees will not be included in the numbers employed under the heading of the aircraft and motor industry. To this extent, therefore, estimates of output based on employment may be on the low side. The final development was the institution of the group scheme, announced in March, 1939, under which existing aircraft firms were grouped in batches of four or five, each group being regarded as a separate unit for both development and production. The object of this system was to reduce the number of designs in service and to facilitate economical and quantity production. In announcing the scheme, Sir Kingsley Wood said: "The organisation of the industry on this basis will facilitate large-scale planning and ordering, and it will have the advantage of lessening the volume of technical work through all stages of design, development and inspection, and of simplifying training, maintenance, store-housing and equipment throughout the service. The scheme will also have the important effect of reducing the dislocation that might result in war if one of the manufacturing units was unable to continue in production. The scheme will embrace not only the firms in the aircraft industry, but the Government factories and the new factories which are being created by such firms as Metropolitan-Vickers."

Since the outbreak of war, progress in the rate of production of aircraft has naturally been shrouded in even greater secrecy than was the case before. Nevertheless, early in October, Sir Kingsley Wood announced that the putting into effect of plans already prepared would result, in due course, in more than doubling the existing rate of output, and foreshadowed a still further increase as the result of plans made since the outbreak of war.

In spite of the very substantial increase in production which took place, the majority of the established aircraft firms have shown reduced profits over the last year. This has been due partly to increased taxation in the form of the Armaments Profits Duty and partly to further revision of the agreement regarding prices between the manufacturers and the Air Ministry. In February, 1939, Sir Kingsley Wood said that the rate of profit on the supply of aircraft, regulated by the McClintock agreement, had been progressively reduced and amounted at that time to approximately 6 per cent. of the cost of the aircraft. He went on to say that British prices were definitely lower than those of corresponding companies in other countries, such as the United States. In order to meet criticism, however, a special investigation was instituted on the subject of aircraft profits.

As a result of this investigation it was decided that, although the agreement was satisfactory when first concluded, it should be modified in view of subsequent changes in circumstances; including the enormous increase in orders and consequent increase in straight-run production, the extent of sub-contracting, and the degree to which it had been necessary, at public expense, to provide capital assets in the shape of factories and works extensions. In July, the Report of the Select Committee on Estimates also stressed the view that prices paid in the field of aircraft contracts had been too high. The Committee stated that they understood that negotiations for a revision of the agreement had already been in progress for some time, and recommended that, in view of the delay in completing these negotiations, any revision should be made retrospective. Shortly afterwards the terms of the new agreement were announced; they provided for a sliding scale of rate of profit in relation to the volume of orders. While the necessity for strict control of aircraft prices is generally admitted, it would seem that the point may now have been reached at which the industry may experience difficulty in raising additional capital and will be forced to rely increasingly on Government assistance in this respect.

The outbreak of war has greatly intensified the problems which the industry will have to face when the war is over. Quite apart from the further extensions to be made to capacity, the banning of exports must seriously affect the industry's power of transition from war to peace time conditions. The only favourable factor is that manufacturers in other countries, even the United States, are being drawn into much the same position; so that, as regards the resumption of export trade at the end of the war, British aircraft builders may not be in such an unfavourable position as some other branches of industry. There will have to be a big transfer of labour into other branches of engineering, however, and as far as possible this should be planned in advance.

In the first eight months of 1939, British exports of aircraft and parts were valued at 4,308,000*l.*, as shown in Table I, herewith, against 3,652,000*l.* in the corresponding period of the previous year. As shown in Tables II and III, however, this increase was not sufficient to enable the British industry to maintain its position in world markets, the proportion by value of total exports from the United Kingdom, Italy, France, Holland and the United States held by British manufacturers falling from 24·5 per cent. in 1938 to 19·8 per cent. in the first eight months of 1939. This decline was accounted for mainly by a sharp rise in exports from the United States, which were swollen by military purchases on the part of Great Britain and France. The total number of aeroplanes exported from the United States, in fact, rose from 876 in the whole of 1938 to 993 in the period January to August, 1939. The latter figure will have included a considerable part of the order for 250 Lockheed bombers for the Royal Air Force, which was placed in June, 1938. It is understood that deliveries against this order were made at the rate of six per week up to

TABLE II.—INTERNATIONAL EXPORTS OF AIRCRAFT. (NUMBER.)

Complete Machines.	1932.	Per cent.	1933.	Per cent.	1934.	Per cent.	1935.	Per cent.	1936.	Per cent.	1937.	Per cent.	1938.	Per cent.	1939, Jan.-Aug.
United Kingdom	300	48·1	234	33·5	298	36·1	453	50·3	448	42·0	506	41·0	506	32·8	—
Italy	27	4·3	52	7·4	23	2·8	100	11·1	36	3·4	39	3·2	152	9·8	48*
Holland ..	17	2·7	7	1·0	15	1·8	14	1·6	33	3·1	63	5·1	11	0·7	39
United States ..	280	44·9	406	58·1	490	59·3	333	37·0	550	51·5	626	50·7	876	56·7	993
Total ..	624	100·0	699	100·0	826	100·0	900	100·0	1,067	100·0	1,234	100·0	1,545	100·0	1,070
Engines.															
United Kingdom	451		409		479		652		625		588		862		—
United States ..	2,356		2,903		1,009		568		945		1,047		1,307		1,220
Total ..	2,807		3,312		1,488		1,220		1,570		1,635		2,169		—

* Estimated on 7 months' figures.

TABLE III.—INTERNATIONAL EXPORTS OF AIRCRAFT. (COMPLETE AND PARTS.) (VALUE £000.)

—	1932.	Per cent.	1933.	Per cent.	1934.	Per cent.	1935.	Per cent.	1936.	Per cent.	1937.	Per cent.	1938.	Per cent.	1939, Jan.-Aug.	Per cent.
United Kingdom ..	1,741	32·0	1,466	28·5	1,922	28·0	2,726	33·4	2,924	29·4	3,676	27·2	5,407	24·5	4,308	19·8
Italy	364	6·7	520	10·1	238	4·8	650	8·0	308	3·1	716	5·3	1,771	8·1	1,224	5·6
France	904	16·7	852	16·6	1,062	15·3	1,740	21·3	1,817	18·2	845	6·3	763	3·5	929	4·2
Holland	153	2·8	85	1·6	71	1·0	134	1·6	267	2·7	348	2·6	89	0·4	268	1·2
United States ..	2,262	41·8	2,231	43·2	3,505	50·9	2,915	35·7	4,638	46·5	7,918	58·6	13,949	62·5	15,023	69·2
Total	5,424	100·0	5,154	100·0	6,888	100·0	8,165	100·0	9,954	100·0	13,503	100·0	21,979	100·0	21,752	100·0

the outbreak of war, leaving about 100 undelivered when the arms embargo was imposed.

These figures are comparatively insignificant beside the numbers it is hoped to deliver to Great Britain and France this year. At the beginning of November, 1939, before the repeal of the arms embargo, The North American Aviation Company had an order for 400 single-engined training machines for Great Britain, and another for 775 similar machines for France. Many of these had already been completed and were awaiting shipment. The Douglas factory was working on a French order for 700 twin-engined bombers. By the end of last year, the total orders on hand with United States manufacturers for Great Britain and France totalled 3,565, and this was subsequently increased to about 5,000. The placing of orders on this scale raises the question of the capacity of the United States industry to supply the requirements of the Allies after meeting the greatly increased requirements of the American Air Force.

At the end of December, Major G. F. Eliot, the United States military expert, came to the conclusion that the prospective deliveries of fighting types to Great Britain and France by the end of 1940 were 3,190, of which 1,530 would go to Great Britain and 1,660 to France. In the case of training aircraft the total is estimated at 1,185, of which 815 will be for Great Britain and 370 for France. Additional orders have been placed, however, since this estimate was made, and it should be noted that Major Eliot considered that sufficient plant capacity was available to make possible total deliveries for export in 1940 of 5,310 fighting and 2,685 training machines. This implies a ninefold increase in United States exports as compared with 1939. The total production of aircraft in the United States in 1938 was only 3,675 machines, but, towards the end of 1939, it was stated that the capacity had been increased to 1,250 per month. In January, 1940, the capacity was given as 1,800 per month, and it was reported in Washington that British purchasing agents had informed manufacturers that they would require not less than 10,000 machines over the next eighteen months.

It is quite clear that the war will cause important changes in the international position as regards the production and export of aircraft. Expansion of productive capacity, far from being confined to the belligerents, will affect every country already producing, or capable of producing, aircraft in the near future. Apart from the United States, the Canadian industry is being developed rapidly, and although the organisation of production in that country for the Royal Air Force is a comparatively recent development, Canadian aircraft exports rose in value from 957,791 dols. in the year ending March 31, 1938, to 2,234,550 dols. in 1938-39.

It is not possible to show German exports of aircraft on a basis comparable with those from the other principal exporting countries, as the German figures include exports of parts of motor vehicles. Table IV, however, shows German exports in this category by value since 1932.

The principal German markets in 1938 were Japan, Holland, Chile, Sweden, the United States, South Africa, Yugoslavia and Turkey. It is impossible to discuss here in detail the productive capacity of the German aircraft industry. Widely differing estimates of output have appeared from time to time in the Press, but it is probable that production lies somewhere between 1,000 and 1,500 aeroplanes per month. This figure is being increased as additional skilled labour is made available. According to one report, the total labour force of the industry was estimated at about 450,000 immediately before the outbreak of war, of which 170,000 were employed by the aircraft firms themselves and the remainder on the production of parts.

The fact that, for the duration of the war, the British aircraft industry is likely to be fully occupied in supplying the needs of the Royal Air Force, with exports suspended except for the export of military planes to Allies, tends to obscure the vital importance in the long run of the market for civil aircraft. The year 1939, however, was one of important developments in this field, and a start was made to improve the position of British manufacturers as regards the production of civil air liners. The month of June, 1939, saw two important developments, namely, the simultaneous issue of the text of the British Overseas Airways Bill and the Report of the Committee of Enquiry into the production of civil aeroplanes. The two were, in fact, complementary, since the former provided for the setting up of a public corporation to acquire and operate the undertakings of Imperial Airways and of British Airways; while the Committee was concerned, having regard to this amalgamation, with methods of co-ordination between aircraft construction, air-line operators and the Air Ministry, in the production of air liners, and the initiation, control and finance of development work.

The need for far-reaching measures has been stressed in these articles for several years. After British Airways had been compelled, in the previous year, to purchase American aircraft, owing to the pre-occupation of the British manufacturing industry with armament orders, Imperial Airways were, in August, 1939, obliged to suspend passenger bookings on the Empire services to Durban and Sydney, largely for the same reasons. Actually, four reasons were given by the company for this decision: (1) Shortage of fleet; (2) shortage of trained personnel; (3) increase in weight of mail; and (4) the desirability of carrying a greater reserve of fuel in each machine. In order to enable the Ensign class to carry full loads to India, the company had to purchase 48 American Cyclone engines. Application was also made to the Air Ministry for permission to buy foreign aircraft, to tide over the period until the British industry should be in a position to accept a large order for a new and improved type of machine. The shortage of trained personnel, of which the company complained, was ascribed largely to the rapid expansion of the R.A.F., and had already brought about a good deal of co-operation on questions of personnel between Imperial Airways and British Airways.

The decision to amalgamate the two companies was undoubtedly right, having regard to the long-term interests of British civil aviation, but many of the conditions and restrictions imposed upon the proposed corporation have been the subject of strong criticism, notably the restriction on the acquisition of aircraft of any type not approved by the Air Ministry. Provided, however, that these restrictions do not seriously hamper the management of the Corporation, it should be in a strong position to push ahead with the development of British civil aviation in the face of the heavily subsidised competition from other countries. At the end of November, 1939, the setting up of the Corporation was announced. The minimum membership prescribed in the Bill was a chairman and five members, but, as a result of the outbreak of war and in the interests of economy, advantage was taken of the Chartered and Other Bodies (Temporary Provisions) Act to provide, by Order in Council, that the Corporation may be established with three members only. The Corporation will be responsible for ratifying the contracts for the purchase of Imperial Airways and British Airways. The total purchase price proposed in the Bill was approximately 3,000,000*l.*, while the Corporation will receive a subsidy up to 4,000,000*l.* per annum, as compared with the previous limit of 3,000,000*l.* In addition, it is permitted to borrow up to 10,000,000*l.*

Perhaps the most important recommendation of the Committee of Inquiry into the Production of Civil Aeroplanes, mentioned above, was that for the setting up of a permanent Civil Aviation Development Committee, which would be responsible for co-ordinating the needs of air-line operators for new types of aeroplanes, with the object of ensuring that production would be concentrated on relatively few types. There would then be a reasonable prospect that a sufficient market might be found to justify production on an adequate scale. It was recommended that the development committee should be independent of the Air Ministry, but that it should work through the Staff of the Directorate of Civil Research and Production. It was recognised that the important question was that of creating a sufficient market for British civil aircraft, and that this could not be provided in this country alone. It was necessary, therefore, to develop machines of outstanding merit at competitive prices. It is clear that, if this consideration was of importance before the outbreak of war, it is likely to be even more so when the war is over, and it is to be hoped that the putting in hand of the necessary preparatory measures will be undertaken in good time. In July, 1939, a pooling agreement was signed between Imperial Airways and Air France. This provided for increased services between Great Britain and France and for the sharing of receipts by the two companies.

The classification of civil aircraft on the Air Ministry List is shown in Table V, herewith, for the years 1929 to 1938. There was practically no change in the number of aircraft registered in the last two years, the figures being below that for 1936. The Civil Aviation Report does not show the subdivision of the total for 1938, but it was recorded that there was a substantial increase in the number of aircraft used by clubs, as the result of the formation of the Civil Air Guard.

TABLE IV.—*Germany: Exports of Aircraft, including Parts for All Kinds of Motor Vehicles.*

Year.	Value.
	£
1932	935,000
1933	775,000
1934	770,000
1935	855,000
1936	1,731,000
1937	3,020,000
1938	5,400,000
1938 Jan.-July	2,960,000
1939 „	3,620,000

TABLE V.—CIVIL AIRCRAFT: UNITED KINGDOM CLASSIFICATION ON AIR MINISTRY LIST.

At December 31.	Regular Air Transport.	Joy Riding, Taxi and Miscellaneous Air Work.	Schools and R.A.F. Reserve Training.	Clubs.	Demonstration, Experimental, Racing.	Private.	Held by Agents for Resale.	Total.	Certified Airworthy.
1929	28	146	82	62	98	184	—	600	413
1930	35	148	98	68	130	333	34	846	615
1931	35	166	104	62	99	385	73	924	707
1932	42	153	134	70	118	402	57	981	731
1933	60	197	132	80	101	408	77	1,055	831
1934	80	190	153	95	99	478	79	1,174	931
1935	122	176	310	141	156	589	41	1,535	1,108
1936	116	177	316	191	144	668	70	1,682*	1,210
1937	117	145	327	198	117	672	84	1,660*	1,170
1938	—	—	—	—	—	—	—	1,666*	1,223

* Does not include 57 machines temporarily unregistered at December 31, 1936; 67 temporarily unregistered at December 31, 1937; and 67 at December 31, 1938.

LITERATURE.

Mechanics Applied to Vibrations and Balancing. By D. LAUGHARNE THORNTON. London: Chapman and Hall, Limited. [Price 36*s.*].

EVIDENCE of a growing recognition of the importance to the engineer of vibrations, both helpful and harmful, is to be found in the number of text-books, several of fairly recent date, devoted to general and particular aspects of vibration theory. Only some notable originality of treatment can be held to justify another volume on the subject; but, judged by that criterion, Mr. Thornton's book is fully justified. One of its major merits lies in the successful application of generalised dynamical techniques to the solution of engineering problems. Probably at least one reason why no serious attempt has been made hitherto to employ the methods developed in a classical treatise like *Mécanique*

Analytique in such a connection is Lagrange's own boast that no diagram of any sort is to be found in his text; but how fertile in inspiration Lagrange's analysis has proved, in the field of communication engineering, can be realised from the consequences that followed Michael Pupin's translation of Lagrange's problem of the string of beads into its electrical counterpart—the loaded cable. It is impossible, of course, adequately to comprehend, or effectively to utilise, a general method of solution without applying it to particular cases and working these down to the numerical stage. The inclusion of a very considerable number of worked problems is an integral part of Mr. Thornton's plan of exposition, and is one of its most commendable features. The problems are of real interest, and are largely drawn from the author's own experience. The assumptions involved in the conversion of each problem into its equations are clearly stated, such approximations as are justifiable, having regard to the reliability of the data, are pointed out, and all essential steps in the accompanying analysis are included.

The book opens with the solution of certain typical examples of engine balancing by the direct application of Newton's laws of motion. Attention is then directed to the fact that this procedure is likely to involve an undue amount of labour in eliminating irrelevant reactions, and that their introduction can be avoided by the more powerful method of attack based on the concept of generalised co-ordinates and the employment of Lagrange's equations. The latter are derived and considered in relation to the dynamics of a particle, a rigid body and a rotating system; and are then applied to the motion of reciprocating engines and to the stability of governors. In the course of Chapter II, Lagrange's equations are made the basis of an investigation into the balancing of locomotives, and a discussion of the various types of valve gear.

The theory of vibrations proper is introduced in Chapter III. After a few representative examples relating to simple harmonic motion, the composition of two such motions at right angles is considered, and this is followed by a discussion of forced oscillations and resonance, with and without damping. The next section is devoted to the general theory of small-amplitude vibrations of a system, having any finite number of degrees of freedom, about its stable-equilibrium configuration. A striking demonstration of the scope and power of the method is afforded by the procedure for obtaining, with the aid of Rayleigh's theorem, an approximation to the natural-vibration frequency in the fundamental mode of a complicated structure having either rigid or pin-jointed connections. Engine-driven alternators and nose-suspended motor drives provide additional illustrations of practical interest.

Chapter IV contains a particularly noteworthy account of the propagation of stress through elastic media. If a source executes some type of non-recurrent motion, the form of displacement that it initiates in the medium will be isolated, and the corresponding wave will be a solitary wave. One-dimensional examples occur in the operation of pile driving, and in the water-hammer effect caused by the sudden closure of a valve in a hydraulic main. Three-dimensional instances include the explosion wave originated by the detonation of a depth charge under water, and the seismic waves resulting from subterranean subsidences. If the motion of the source is periodic and persistent, it communicates to the medium a regular sequence of identical forms of displacement, which will be transmitted through the medium as a train of progressive waves. It is shown that continuous wave motion of this sort implies the possibility of transmitting power through a pipe after the manner first studied in detail by Constantinesco. Other topics, such as reflection, refraction, dispersion and distortion, are treated more convincingly and realistically than in the average physics text-book, and should appeal strongly to students of this subject, as well as to practising engineers.

Chapter V deals first with the transverse vibrations of slender uniform beams subject to various standard types of constraint. The scope of the analysis is then widened to embrace struts and ties, *i.e.*, beams under thrust or tension, Rayleigh's theorem being again employed for the approximate evaluation of the corresponding fundamental frequencies. One deduction from the further extension to composite framed structures is that the addition of material to a structure subject to earthquakes may lead to an increase in the damage done under conditions of resonance. Consideration of the circumstances attending the transmission of transverse waves along a beam brings to light interesting features having a bearing upon such matters as the "jump" of guns. The simplest type of two-dimensional problem is that presented by the small vibrations of a uniform taut elastic membrane. The rectangular and circular membranes are both amenable to analysis, and to their respective modes of vibration correspond characteristic nodal patterns. For the analogous problem of the thin flat plate an exact solution is generally impracticable, though approximate solutions are obtained when the plate area is rectangular and circular. Preliminary consideration is next given to the much more involved subject of the vibrations set up in the fuselages of aircraft by unbalanced forces of a periodic character due to engine or airscrew, and attention is also directed to the perturbations due to gyroscopic forces developed during rapid manœuvring. The chapter concludes with the derivation of Hamilton's canonical equations of motion, the most general relations of formal dynamics, and a brief account of the principle of least action.

Chapter VI commences with an investigation into the whirling speeds of shafts mounted in various types of bearings, and the possibility of finding a length of uniform shafting which can be treated as equivalent to a specified non-uniform shaft. The general theory is then taken up on the assumption that the shaft in question can be regarded as built up of a finite number of rigid discs suitably linked together. One important result which emerges is that the transverse vibrations of the shaft will be accompanied by torsional vibrations, the relative importance of which depends upon the extent to which the shaft is out of balance. The effect of gearing as a possible contributory factor in the vibratory motion of shafting is also considered. The general theory is likewise of considerable assistance in connection with the vibrations which may arise in the rotor of a steam turbine, enabling estimates to be formed of the critical speeds of a structure composed of disc, blading and shrouding. The final chapter summarises in broad outline what has been studied in detail in the body of the text, and might advantageously be perused at the outset as well as at the end. It also indicates further applications of the theory, as, for example, to geophysical prospecting, now widely employed in locating the salt domes with which oil deposits are associated, to the design of buildings to withstand earthquake shocks, and to marine and aerial surveying.

The conscientious reader of this volume cannot fail to be impressed by the thoroughness with which the author has carried out his investigations, and the careful consideration he has given to finding the clearest method of presenting his conclusions. The result is a distinguished contribution to the understanding of the multifarious aspects of vibration theory, which are of vital concern to both engineer and physicist. It will undoubtedly come to be ranked as an authority for consultation on all kinds of vibration problems.

Theory and Design of Valve Oscillators. By Dr. H. A. Thomas. Monographs on Electrical Engineering. Vol. VII. London: Chapman and Hall, Limited. [Price 18s.]

The thermionic valve consists of an envelope, more or less completely exhausted, and containing, in addition to an electron source, one or more electrodes of suitable structure, independently mounted in some predetermined relation to one another. In the present volume, Dr. Thomas is concerned with a particular property of the thermionic valve, viz., that of maintaining undamped electric oscillations in an associated LRC series circuit. The valve enables the energy required to make good the resistance and radiation losses to be drawn from a direct-current source and supplied to the tuned circuit, suitably phased and at the correct frequency to secure maintenance. For purposes of analysis, it is convenient to regard the valve, in this connection, as equivalent to a negative resistance for small current values. Actually, however, the non-linear nature of the valve characteristic ensures that its effective resistance becomes positive for currents exceeding a certain magnitude. Thus, while the amplitude of an incipient oscillation will build up at the outset, an oscillation of which the amplitude surpasses a certain critical value will be damped down in the normal manner. In between will be located a value of the amplitude such that the energy supplied to the system during a certain fraction of the cycle precisely balances that dissipated during the remainder of the cycle, and to which corresponds a stable regime of sustained oscillation.

The various oscillators considered fall into three main groups:—(i) the dynatron oscillator, in which the grid of the valve is maintained at a higher potential than its anode, and in which secondary emission causes a decrease in current with increase of voltage; (ii) the various types of oscillator based on the regenerative principle, in which some form of coupling is provided between the grid and anode circuits to enable the necessary fraction of the output energy to be fed back into the input circuit; and (iii) relaxation oscillators, the frequency of which depends not on the resonant frequency characteristic of the particular circuit concerned, but on its time constant. A discussion of the general maintenance conditions for each of these classes of oscillator is followed by an investigation of the amplitude and wave form of their oscillatory currents, and the efficiency of the corresponding oscillation generators. Since any self-maintained oscillating system must combine with the passive tuned circuit an active circuit component, such as a valve, the frequency of oscillation of the system as a whole will differ, to some extent, from the natural frequency proper to the tuned circuit. The causes and possible extent of this frequency shift are considered in Chapter IV. Quite independently of what the actual frequency of the oscillating system may be, it is usually desirable, and often essential, that it should maintain its value within narrow limits under normal operating conditions. The various causes of frequency drift are then thoroughly explored. A full account is given of the means available, both as regards choice of circuits and design of components, to secure an oscillator exhibiting a high degree of frequency stability. The concluding chapter is devoted to mechanical and electrical methods of automatic monitoring.

More comprehensive practical details are given in the latter half of the book, which is largely based upon the author's own extensive researches. Comparatively few misprints were noticed, and most of these are sufficiently obvious. On page 225, it is stated that two condensers of different dielectric materials may be connected in parallel to give zero resultant temperature coefficient, while the equation immediately following appears to have been derived on the assumption that the two condensers are series connected. In spite of a slight impression of lack of balance between theory and practice in parts of the text, this monograph is a welcome addition to the literature dealing with applications of the thermionic valve.

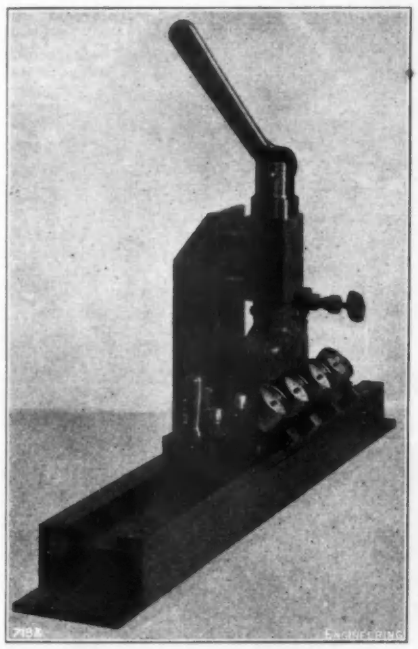
Australian Shale-Oil Industry.—It is stated in a recent issue of our Australian contemporary, *The Commonwealth Engineer*, that Messrs. National Oil Proprietary, Limited, expect shortly to commence the commercial production of oil from shale at Newnes, New South Wales. It is anticipated that the initial output will be at the rate of 5 million gallons per annum, but that this will soon be increased to 10 million gallons annually, with an ultimate annual production of 30 million gallons. The shale yields from 80 to 100 gallons of oil per ton.

Production of Silver in Canada.—Last year the production of silver in Canada totalled 22,775,375 fine oz., compared with 22,219,195 oz. in 1938. Upwards of 42 per cent. of the 1939 total was manufactured in British Columbia, the largest single producer in that province and, in fact, in the whole of the Dominion, being the famous Sullivan mine, where silver is recovered in association with lead and zinc. Silver is also produced in quantity in the nickel-copper mines of Ontario, in the Yukon Territory, in Manitoba, in Saskatchewan, and in Quebec.

PNEUMATIC FUSE-TESTING MACHINE.

THE machine for testing shell fuses, illustrated in the accompanying figure, has recently been introduced by Messrs. B.E.N. Patents, Limited, High Wycombe, and has been designed for testing the type of fuse which is fitted with small copper cover plates or sealing discs. The nose portion of the fuse is recessed to take the copper disc, which is fitted into position with a coating of shellac cement round the edge of the disc. The top of the fuse is then rolled or spun on to the cover plate to ensure a pressure-tight seal. The fuses are required to withstand an air pressure test of 30 atmospheres, applied from the outside, to prove the effectiveness of the air seal at the cover plate, and to see that the plate does not rupture. The large quantities of fuses to be tested, and the fact that female labour is invariably employed on the test, necessitate the use of a machine which is compact, easily operated, and rapid in action.

As will be clear from the illustration, the machine consists essentially of a cam-operated vertical slide to which is attached a pressure head. The latter is connected to an air receiver at the required pressure by a length of special flexible air hose and a handwheel



valve. The pressure head, which may be arranged to test either one or two fuses per operation, carries a corresponding number of internally-coned sealing rings arranged with a taper corresponding to that of the fuse cap, so that when the cam lever is depressed, the coned rings make intimate contact with the nose of the fuse and effect a perfect air seal. The bed of the machine is arranged to take a sliding magazine carrier as shown, this carrier accommodating two, four or six fuses so that these can be readily moved into position beneath the pressure head for each test operation. The fuse magazine is equipped with an independent relief valve and pressure gauge for each fuse carried, these gauges being inclined at a suitable angle to enable them to be easily read by the operator. In loading the magazine, each fuse is dropped on to a composition locating ring which ensures a perfect air seal when the pressure head is in the testing position. Space for magazines are providing for speeding up the work, one operator loading and unloading the magazines while a second operator carries out the actual test.

The particular machine illustrated is a duplex model with two sealing rings in the head, and with a magazine for four fuses. It is arranged for hand operation, but it may be mentioned that machines can be supplied for foot operation with either a single or duplex head, and with one or more magazines. Various types are available to deal with the different sizes of fuses now in production.

MANUFACTURE OF TELEPHONES IN INDIA.—It is stated in a recent issue of the *Journal* of the India Society of Engineers that 2,450 telephone hand sets were produced in the Government Telegraph Workshops at Alipore, Calcutta, during the year 1938-39.

LIGHTWEIGHT PASSENGER ROLLING STOCK.*

By W. A. STANIER, M.I.Mech.E.

IN this paper no attempt is made to compare British with American practice, the requirements being so different. In Great Britain, largely owing to high platforms at the stations, the maximum width over the cylinders of a locomotive is 9 ft., and the maximum height 13 ft. 6 in., but generally only 13 ft. 1 in. The maximum weight on an axle is 22 tons 10 cwt. (50,000 lb.), and this limits the tractive effort of a six-coupled engine to about 40,000 lb. The maximum weight of a train, therefore, is not more than 600 tons, so that, to enable a reasonable number of people to be carried with the comfort necessary for comparatively short runs, it has been the practice to build coaches 60 ft. in length and weighing 30 tons. In the past this was achieved by having a steel underframe and a body frame of wood with wooden panelling and roof, but for many years now the general practice has been to have a heavy steel underframe on which is mounted a wooden-frame coach body, sheathed in steel and with a steel roof.

The weight per passenger seat in a third-class corridor coach is about 1,600 lb. Fig. 1, on page 166, shows this type of construction. Development consisted for many years in refinements aimed at improving comfort and reducing manufacturing costs without departing from the conventional form. Experiments with alternative methods of construction have been made, such as all-steel riveted construction or the use of aluminium alloys, but the advantages have been indecisive and no continued development has taken place. Since 1932, however, serious attempts have been made to reduce weight by new methods. The introduction of electric welding and the availability of suitable high-tensile steels have been the corner stones of recent progress, and have permitted a freedom in design formerly unattainable.

It will be of interest to describe briefly the stages through which development has passed in the last seven years on the London Midland and Scottish Railway.

First Stage.—The first portion of the old standard design to be modified was the timber body framing. Tests showed that about 106 small parts per coach could be eliminated by improving the fastening of the pillar feet to the timber bottom sides, and substituting bolts for coach screws. It was a short step thence to welding the pillar brackets directly to the solebar. Details of these tests have already been published.† On the first coach to which it was applied, opportunity was taken to embody all-welded underframe and bogies. The actual number and arrangement of the members closely followed riveting practice and mild steel was used. Some advantage was, however, taken of the elimination of rivet holes to reduce some of the sections. The underframe showed a reduction in weight of 1,400 lb., or 8·5 per cent., and the two bogies of 840 lb., or 3·6 per cent., on riveted construction. The completed coach weighed 28 tons 16 cwt. while a similar vehicle of standard construction weighed 30 tons 6 cwt.

Second Stage.—The foregoing represented the utmost attainable with normal materials and on the principle of a coach body simply resting on the underframe and not designed to take part of the load. In the second stage, high-tensile structural steel was introduced for underframe and bogie, while the conception of body and underframe as separate entities was partially abandoned. The underframe was designed on entirely new principles, in that it was made up of light sections and employed truss construction. The load was divided between two longitudinal centre beams and the two body sides, the latter being each designed as a complete truss. The cantrails, being of steel section, acted as one boom and the solebar as the other. Timber pillars were, however, retained, these being braced by light steel members to take the shear. The whole body side was treated as a Vierendeel truss. Each of the longitudinal members, both beams and body sides, was made strong enough to carry its share of the load.

A high-tensile structural steel was used for the underframe, with a tensile strength between 37 tons and 43 tons per square inch. The same material was used for the welded bogies, which were redesigned to provide lighter sections. Axle guards were welded as an integral part of the solebar, and the bolster and swing beam were fabricated. The net saving in weight, as compared with the first and with the standard construction, is shown in Table I, herewith.

* Paper prepared for presentation at the American Summer Meeting of the Institution of Mechanical Engineers, September, 1939. Abridged.

† "Some Developments in Railway-Carriage and Wagon Construction," by P. L. Henderson. *Jl. Inst. C.E.*, vol. 3, page 231 (1935-6).

Third Stage.—The redesigned underframe and body side and the welded construction were continued in conjunction with articulated bogies on the well-known Gresley principle. High-tensile structural steel in this case was only used for cantrails and solebars, the remaining parts, including the whole of the bogie, being of mild steel. Wooden pillars were still retained. Of a total saving in weight of 18·3 per cent., it is estimated that 10·4 per cent. arises from the articulation and consequent reduction in the number of bogies.

The Coronation Scot train, which has been exhibited at the 1939 World's Fair in New York, includes three two-car articulated units which follow the design and construction outlined above. The total weight of the six articulated vehicles is 186 tons 12 cwt., while the corresponding vehicles of previous standard London Midland and Scottish Railway construction weigh 213 tons 3 cwt. The weight of the whole eight-car train exhibited is 262 tons 10 cwt., compared with a weight of 289 tons 13 cwt. for the standard construction.

Latest Form of Design and Construction.—The first portion of the London Midland and Scottish Railway to be electrified was the 18¼ miles of line between Liverpool and Southport, which was converted as early as 1904. Although additions have been made to the rolling stock since then, the bulk of the vehicles are thirty-five years old, and their complete replacement was decided upon. The original coaches were of the open saloon type, 10 ft. wide. In the new vehicles, further development on the lines described was decided upon, all-steel construction and spot welding for body panels being introduced. The separate identity of the body as distinct from the underframe was finally abandoned and the method of design already tentatively adopted was carried to its logical conclusion.

The design of underframe and body is based on the Vierendeel truss. It consists in a simplified form of a rigid frame incorporating parallel top and bottom booms with equal sections, and a number of vertical

TABLE I.—*Weights of Third-Class Corridor Coaches.*

Type of Construction.	Welded Lightweight.	Welded Standard.	Riveted Standard.
	t. c. q.	t. c. q.	t. c. q.
Complete vehicle ..	25 19 3	28 16 0	30 6 0
Underframe (less brake work, etc.)	4 14 3	5 4 3	5 10 2
Bogie	4 14 3	5 0 0	5 3 2
Tare weight per passenger, lb.	1,385	1,535	1,615

columns, which are rigidly connected to the booms, to transmit bending moments as well as tension, compression, and shear. The working out of this form of truss, and its application to rolling stock, was undertaken in the design office of the London Midland and Scottish Railway. Fig. 2, on page 168, shows the body-frame unit of this stock, and it will be seen that, if panels and light-section subsidiary members are left out of account, the underframe, body side, and roof resemble the Vierendeel truss in general form. The panels are $\frac{1}{16}$ in. thick, and where they are unsupported over any considerable area it may be assumed that their resistance to buckling will not be great enough to justify taking it into account. Their presence, however, does add to the factor of safety of the whole structure. The main underframe members form the bottom boom of the truss, the roof structure forms the top boom of the truss, and the body-side pillars perform the functions of the columns.

Fig. 3, on page 168, shows the essential details of the body sections, and Fig. 4, on page 169, a body side arrangement. It will be noted in Fig. 4*a* that the individual pillars naturally fall into groups, each comprising two pillars in close proximity, and it seems a reasonable approximation to assume that the short cross-members and small sections of panelling between two such pillars cause them to act together as one unit. Each pair of pillars, therefore, has been regarded as one column of the truss acting at the vertical centre lines as indicated. A typical section of two pillars (comprising column 2) is shown in Fig. 3*b* and the corresponding properties are indicated.

Two features of difference between this case and the more normal form of the Vierendeel truss must be emphasised. First, the top and bottom booms are not equal in section or moment of inertia; and, second, the pillars are curved, due to the coaches being wider at the "waist" than at the top or bottom. The method of allowing for the first difference will be made clear in the analysis. The curvature of the pillars has two effects. The stresses induced by the tension or compression in the columns will be greater, due to the eccentricity of the forces involved, and this has been allowed for. Also, the bending action at the top and bottom of the pillars will be accompanied by some

degree of twisting. This has been neglected in the calculations, and it was anticipated that the consequent error would not be excessive, as the twist is resisted by the horizontal members, which are otherwise not taken into account. It will be noted in Fig. 3 that the waist rail has been made fairly rigid about a vertical axis for this reason.

The coach side will be considered loaded as indicated in Fig. 4*b* with a distributed load of 0·206 ton per foot run, representing half the estimated weight of the coach with passengers and an allowance for overload. The resulting shearing-force diagram is given in Fig. 4*c* and Fig. 4*d* (full lines) shows the bending-moment diagram for the side as a whole. The bogie centre reaction of 6·85 tons is assumed divided between the centre lines of columns 2 and 3 in inverse proportion to its distance from each. This modifies the bending-moment diagram in the manner indicated by the broken line. The bending moments above the broken line are taken as being resisted by the underframe section alone between the two columns. The resulting figures for the supporting forces under columns 2 and 3 are :—

Under column 2...	...	3·11 tons
,, ,, 3...	...	3·74 ,,

As it is assumed that the deflection of the roof at all columns is the same as that of the underframe, it follows that the bending moments in each due to direct loading will be proportional to the moments of inertia of their sections. Thus, the moments of inertia of half roof section = 231·4 in.⁴; the moment of inertia of half underframe = 316·1 in.⁴; the bending moment carried by roof = $\frac{231\cdot4}{(231\cdot4 + 316\cdot1)} = 0\cdot42$ of full load; and the bending moment carried by underframe = 0·58 of full load. The chain line in Fig. 4*d* divides the large bending-moment diagram in these proportions, and thus the portion between this line and the base line represents the bending moments on the roof; while the portion between the broken and full lines represents the bending moments on the underframe, due to the direct loads and tensions or compressions in the columns. It follows that the tensions in the columns will be such as to transmit to the roof 0·42 of the load on the half coach, leaving the residual 0·58 of the load to be borne by the underframe.

This analysis is illustrated by consideration of column 2 (Fig. 4*a*). Columns 1, 2 and 3 are shown diagrammatically in Fig. 3*c* with the necessary dimensions.

Let t_1 be the tension between solebar and roof in column 1, due to the load between A and B;
Let t_1' be the tension in column 1, due to the load between columns 1 and 2 (B and C);
,, t_2 be the tension in column 2, due to the load between columns 1 and 2;
,, t_2' be the tension in column 2, due to the load between columns 2 and 3 (C and D);
,, t_3 be the tension in column 3, due to the load between columns 2 and 3.

Then

$$t_1 = \frac{4\cdot5}{12} \times 0\cdot206 \times 0\cdot42 = 0\cdot033 \text{ ton.}$$

$$t_1' = t_2 = \frac{64\cdot5}{12} \times \frac{0\cdot206}{2} \times 0\cdot42 = 0\cdot233 \text{ ton.}$$

Then $t_1 + t_1' = T_1$ (total tension in column 1) = 0·266 ton.

$$t_2' = 0\cdot42\left(\frac{66}{12} \times \frac{0\cdot206}{2} - 3\cdot11\right) = -1\cdot067 \text{ tons,}$$

and

$$T_2 = t_2 + t_2' = 0\cdot233 - 1\cdot067 = -0\cdot834 \text{ ton.}$$

So that there is a compression in column 2 of 0·834 ton.

Fig. 4*e* and *f* show the bending-moment diagrams for underframe and roof respectively, with the column moments taken into account. These are the same as shown in Fig. 4*d*, but separated for further treatment. The curve in Fig. 4*e* represents the full bending moment, less relief, due to pillars, of 0·42 of the load. The diagram for the roof, Fig. 4*f*, is composed of straight lines, while that for the underframe is curved, but the number of columns is such that the difference in shape is slight. As is usual in the approximate solution of the Vierendeel truss, it is assumed that a point of contraflexure exists at each mid-point between columns, and horizontal lines are therefore drawn through these points in Fig. 4*e* and *f*. The ordinates between these lines and the base lines of the bending-moment diagrams then represent to scale the bending moments in the underframe or roof due to the actions of the columns, which are opposite in sign to the bending moments due to the direct loading and column tensions. The length of each vertical joining these horizontals represents to scale the bending moments in the respective columns at the junctions between them and the underframe, Fig. 4*e*, and the roof, Fig. 4*f*. It will be observed that the bending moments in the columns are not equal at top and bottom, being greater at the bottom than at the top in the proportion of 0·58 to 0·42. Thus the point of contraflexure in the columns is nearer the roof, being situated so that it also divides the line joining the roof and the underframe in this ratio.

The bending moment in column 2 at its junction with the underframe is 10·61 ton-in. Referring to Fig. 3*a*, it will be seen that the junction of the actual pillars with the underframe is 5·29 in. above the neutral axis of the latter. Taking the point of contraflexure in the column as 0·58 × 83·6 = 48·5 in. above the underframe neutral axis, it follows that the maximum bending moment in the actual column is :—

$$\frac{(48\cdot5 - 5\cdot29)\,10\cdot61}{48\cdot5} = 9\cdot45 \text{ ton-in.}$$

The shear in the column at the point of contraflexure will be $\frac{10\cdot61}{48\cdot5} = 0\cdot219$ ton. The shear in column 1, computed in the same manner, is 0·059 ton, and the shears in the two columns are opposite in direction. Thus a tension exists in the underframe between columns 2 and 3 (and an equal compression in the roof) of (0·219 − 0·059) = 0·160 ton. Reverting to column 2, and using the properties given in Fig. 3*b*, the maximum stress in the column may be computed as follows :—Direct load = 0·830 ton compression; eccentricity of loading due to curvature of pillars = 4·375 in.; bending moment due to non-axial loading = 0·83 × 4·375 = 3·63 ton-in.; maximum stress due to direct load

$$= \frac{M\,y}{I - \frac{P\,l^2}{C\,E}} + \frac{P}{A}, \text{ where C = a constant}$$

$$= \frac{3\cdot63 \times 1\cdot25}{1\cdot54 - \left(\frac{0\cdot83 \times 68\cdot25^2}{24 \times 13{,}000}\right)} + \frac{0\cdot83}{1\cdot37}$$

= 3·58 tons per square inch; bending moment in column = 9·45 ton-in.; stress at solebar junction due to this = $\frac{9\cdot45}{7\cdot46} = 1\cdot27$ tons per square inch. The sum of these two stresses is 4·85 tons per square inch.

The general dimensions necessitated the use of low cantrails; the height of the pillars is only 5 ft. 8¼ in., so that, where doors occur, it is necessary to encroach on the roof to obtain a doorway height of 6 ft. 3 in. Thus the cantrails are broken at each doorway and discontinuities exist in the roof section. Moreover, at two doorway positions on each body side, sliding doors are used, and the pockets for these reduce the body side frame thickness. The "equivalent doorway," including the pockets for the sliding doors, is 8 ft. 6 in. wide.

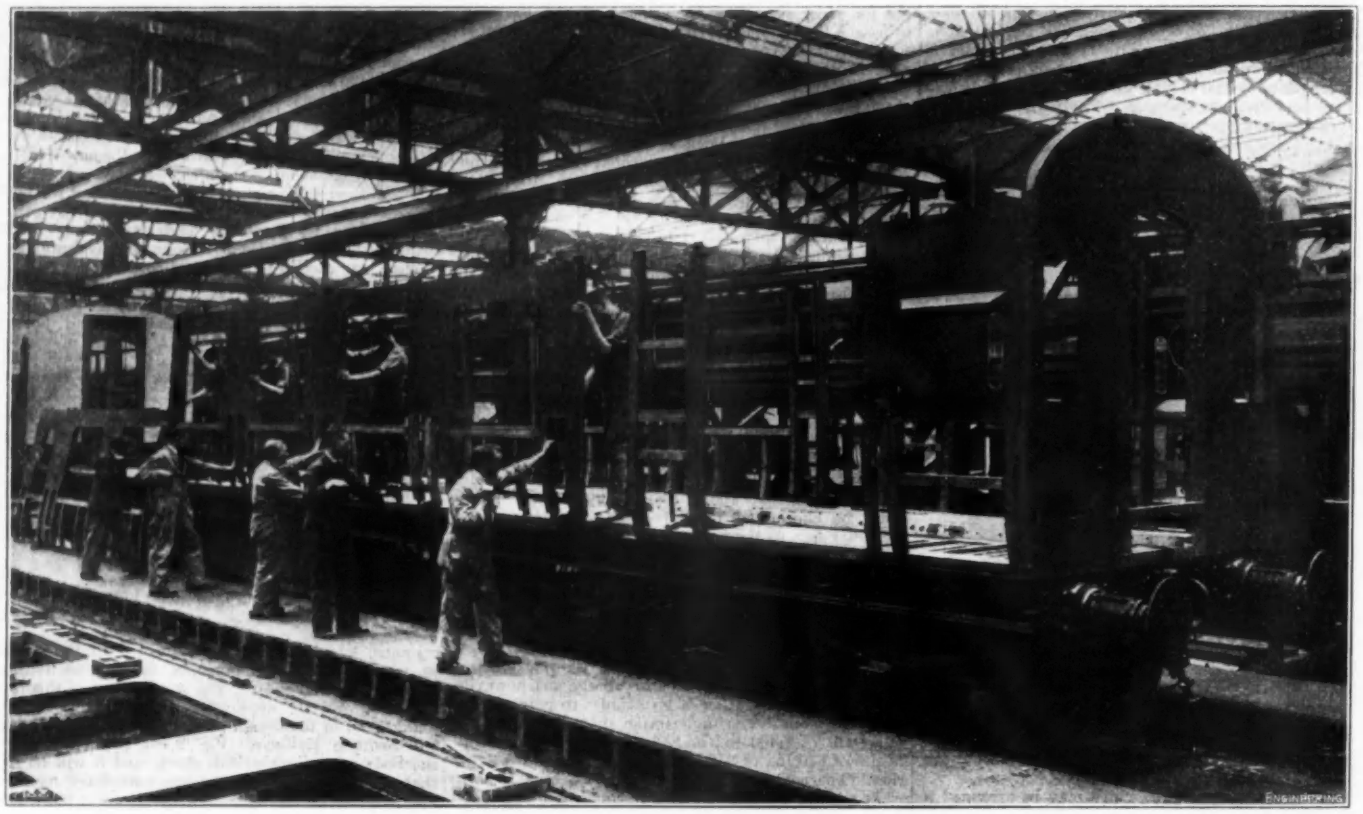


FIG. 1. CONSTRUCTION OF STANDARD PASSENGER COACH.

Fig. 3 shows, on the left, a section through a doorway. It will be seen that a specially rigid pressed-steel lintel member X has been introduced over the doors to compensate for the cutting away of the cantrail section Y in Fig. 3*a*, and for the reduction in depth of the overall roof section. To have a sufficiently strong door pillar, it has been found necessary to make it thicker than the rest of the outside sheath of the door pocket. Thus the door pillars project slightly from the body-side surface. Also, to prevent buckling of the large area of the panel outside the door pocket, a series of thin corrugated pressed pillars has been provided. This is shown at W in Fig. 2. The underframe portion is shown in detail in Figs. 5 and 6, page 169. While it cannot be claimed that the foregoing constitutes an exact analysis of all the stresses involved in the design, its validity has been demonstrated by the overload tests on the finished vehicle.

Bogies.—These follow the usual lines of London Midland and Scottish carriage-bogie design. The determination of the bending-moment diagram for such a bogie has been published in the paper already cited on page 165, and in the fabrication by welding of these bogies it has been found desirable to give special attention to the junction between the solebars and cross-members. The gussets have been designed to reduce concentrations of stress at corners and at the same time to leave the joints as strong and flexible as possible. The gussets are not butt welded to the members, but overlap them, this method producing a more reliable joint. The free edges are curved to reduce rigidity. A saving in weight has also been effected by using a smaller wheel—3 ft. in diameter on the new coaches, as compared with 3 ft. 7½ in. on the older types.

Construction.—In considering the description which follows, it is important to note that, although the conditions of limited production prevail, the necessary output being only three coaches per week, unit assembly has been achieved on new lines, but based to some extent on the construction of the old type of wooden car. The unit-assembly method was adopted, although the process had to be introduced into shops already engaged in the construction and repair of vehicles of the normal type.

The presses, guillotines, etc., producing the pressings were laid down in one bay of an existing sawmill, the equipment consisting of the following :—

1. A 300-ton press, 16-in. stroke, 12 strokes per minute, 11 ft. 3 in. between uprights. This is used for pressing the main steel sections, such as carlines, body pillars, door-head pressings, door pillars, etc. It is driven by a 30-h.p. electric motor.

2. A 50-ton press brake with a 6-in. stroke, 40 strokes per minute, with a table 1 ft. by 9 ft. This machine, using Vee-tools, deals particularly with partition channels and Z-sections, turning the edge of special body pillars, angle sections, etc.

3. Two 2 ft. 6 in. open-fronted presses. These are of 60 tons capacity, giving a stroke of 4 in. and 50 strokes per minute.

4. An 18-in. diameter saw used for cutting sections to length.

5. Two guillotines to deal with sheet up to 11 ft. wide.

6. Three bench presses of 6 tons capacity.

The steel used is specified as steel sheet suitable for deep drawing or pressing, double pickled and oiled. It is rolled from material with a tensile strength of 28 tons to 32 tons per square inch, and is subsequently annealed to give it a tensile strength of approximately 24 tons to 26 tons per square inch, a figure which is somewhat increased after pressing. It is only possible to describe one or two of the many special tools developed, and those for carlines and pillars are selected.

The finished sections for the carlines are Z and angle sections. Hence, in designing the tools, it was necessary to arrange for the sections to be pressed in pairs to enable them to be of symmetrical form, that is of channel and "top-hat" shape shown in Fig. 7, *a* and *b*, respectively, on page 169. Separate tools were made for each section, an assembled tool being shown in the 300-ton press illustrated in Fig. 9, on Plate IX.

Dealing with the top-hat section, the contour of the tools is the actual contour of the carline required, the other features, such as pressure-pin positions, holding-down bolts, etc., being governed by the design of the press. The tools are of cast iron. After machining the working faces, the tools were bedded together by hand grinding and filing, the bottom outside portion being taken as correct, as this had been previously machined to a template. Allowance was made for the thickness of the material (16 S.W.G.) during the bedding. The bottom centre portion was then fitted until parallel with the outside pieces. After the two top outside portions had been fitted to the bottom outside portions, the top centre portion was next made parallel to the top outside sections, a depth gauge being used for checking. Finally, a minimum radius for the drawing edge of the tools had to be carefully selected. For the carline tools there were four edges over which the material has to be drawn. A radius of $\frac{5}{32}$ in. was found to produce a good pressing.

The blanks prior to being put into the press are smeared with a compound of the following composition :—

	Per cent.
Talc powder	29·5
Burning oil	18·0
Paraffin oil	5·0
Colloidal clay	2·0
Oleic acid	1·0
Triethanolamine	0·4
Sodium silicate	0·1
Water	44·0

The blank is held by the outside portions of the tools during pressing, and is gradually drawn over the bottom centre portion. Pressure pins acting on the movable bottom side portions of the tool eject the finished carline. In a long thin pressing such as this, slight distortion may be experienced on release, and it is set to correct contour with timber blocks in a 60-ton press before slitting down the centre to form two Z-section carlines by means of nibbling tools in a 6-ton press, as shown in Fig. 10, on Plate IX. The final operation of punching the necessary holes is carried out in a 6-ton bench press to a template clipped on to the carline.

In the case of the pillars, of which there are seven different types in 14 S.W.G. steel sheet, the same methods of fitting and bedding the tools were adopted. In this case, the radius of the edges of the tool was $\frac{3}{16}$ in. As an example, the sliding door pillars are shown in Figs. 11 and 12, on Plate IX. This pressing had to be carried out in three operations. Fig. 11 shows it in a 6-ton bench press for trimming, and Fig. 12 illustrates the tools for the final pressing operation.

Fabrication of Underframe and Bogies.—The high-tensile steel for underframes and bogies has the following specification :—

Carbon, per cent.	0·20 max.
Silicon, ,, ...	0·30 ,,
Manganese, ,, ...	1·4-1·6
Sulphur, ,, ...	0·06 max.
Phosphorus, ,, ...	0·06 ,,
Chromium, ,, ...	0·10 ,,
Copper ,, ...	0·60 ,,
Yield Point	23 tons per sq. in.
Ultimate breaking load ...	37 ,, ,,
Elongation on 8 in.	19 per cent. (min.).

Four types of underframe of similar construction were required for the Liverpool and Southport stock, each of which had to be built in correct train order. This was made possible by constructing a special underframe jig designed to locate all the members of the four underframe layouts.

A notable feature of the location is a specially-devised hinged two-way cramp which also served as a location stop, Fig. 8, on page 169. To identify the respective location stops and cramps with the types of underframes, a colour scheme was adopted. A distinctive colour was given to all stops applicable to one type of frame, a second colour to all stops for a second type of frame, and so on. To simplify construction further, all the building material and members were marked with paint of similar colour, thus identifying them with types of underframes. In this manner, it is possible to change from one type of frame structure to another without any jig layout modification, and without loss of setting time.

The general construction of the underframe is split up into two major operations :—(1) The centre longitudinal girders are constructed initially on a separate jig as a box girder ; (2) the underframe is then completely assembled, upside down, in the main assembly jig. The longitudinal girders are assembled on a level jigging base having correctly positioned location points, where allowance has been provided for minor distortions affecting camber dimensions. By this means a completed section to correct camber is produced to within $\pm \frac{1}{8}$ in. of drawing dimensions. This tolerance is important, as with this design of frame it has been found that the camber of the longitudinal forms the foundation for the final underframe camber. Two such girders are assembled with suitable cross-members on a portion of this same jig base to form the box-girder unit, and all welds presented in a normal position as regards gravity are completed. The main assembly comprises the placing of the longitudinal girder unit together with the main solebars, crossbars, buffing drawgear and headstock members in the main welding jig, and clamping the whole together. This allows great accuracy during the subsequent welding operation. The vertical and overhead seams are carried out by taking the assembled underframe out of the main jig and turning it into a second building position to enable the remaining welds to be made in a normal gravity location, as shown in Fig. 13, on Plate IX.

The motor bogie is noteworthy from the constructional point of view as it is made up of welded plate sections to give lightness with adequate strength.

Distortion problems abound, but suitable jigs and welding procedure have been developed to give the necessary accuracy. The production of solebars and crossbar members on separate jigs forms the principal work. Fig. 14, on Plate IX, shows one of the latter for a motor bogie, and the platform for the support of the nose end of the motor may be seen. Final assembly is carried out on a fixed location jig, where all the major parts are partly welded. The bogie is then lifted and placed on trunnions which allows easy turning by manual effort so that all welds may be completed in a normal position, as shown in Fig. 18, on page 172. The amount of welding per bogie is about 750 ft., while the underframes require 1,400 ft. of welding, chiefly consisting of alternating-current fillet welds of ¼ in. leg length, a high-grade 6 or 8 S.W.G. coated electrode being used.

Assembly.—In the assembly shops, body sides, ends, partitions, and roof are built up as units and erected on the underframe in a definite sequence of operations. Fabrication of the components proceeds simultaneously in the various jigs, which are so disposed that the parts are available as required for assembly on the underframes, which have been run in on bogies from an adjacent shop.

Welding Equipment.—Before dealing, in turn, with the various operations, a description of the welding machines is desirable. Spot welding has been widely adopted for panel fabrication, and machines are provided as follows :—

(1) *For Side Panels.*—One electrical resistance spot welder arranged for two welding pincers. Welding power, 300 kVA. Hydraulically-operated welding pincers for suspension over gantry, 12-in. working clearance between pincer arms, 48-in. depth of throat of pincers. Preheating device.

(2) *For End Panels, Draught Screens, Etc.*—One electrical resistance spot welder arranged for two welding pincers. Welding power, 300 kVA. Hydraulically-operated welding pincers for suspension from gantry. First pincer, 22-in. working clearance between pincer arms, 63-in. depth of throat of pincer. Second pincer, 22-in. working clearance between pincer arms, 20-in. depth of throat of pincer.

(3) *For Roof Panels.*—Two electrical resistance spot welders. Welding power, 220 kVA. Hydraulically-operated portable welding pincer, 18-in. working clearance between pincer arms, 30-in. depth of throat of pincer.

Each welding machine is equipped with a variable-pressure cycle, special energy relay, and preheating device. There are six weld taps to regulate the main contactor current and a similar number to regulate the preheat current. The initial pressure can be set by means of pressure gauges graduated to 80 lb. per square inch. Another pressure gauge on the control cabinet indicates the actual welding pressure, which may be of the order of 1,200 lb. or more. The time of the weld is controlled by the energy relay, which records the amount of energy entering the weld in terms of volts × amperes × seconds.

The spot-welding machines can be arranged for the following cycles :—(1) Welding without preheating, initial pressure sustained throughout complete cycle without pressure dwell after the weld ; (2) welding without preheating, three-pressure cycle, that is, initial pressure before welding commences, back pressure shortly after the main contactor closes, and recompression at initial pressure value immediately the main contactor opens ; (3) welding with preheating, initial pressure sustained through complete cycle, with or without pressure dwell after the weld ; (4) welding with preheating and fully automatic three-pressure cycle. Preheating is mostly used for galvanised material, and normal setting for two thicknesses of 16 S.W.G. panel would be :—

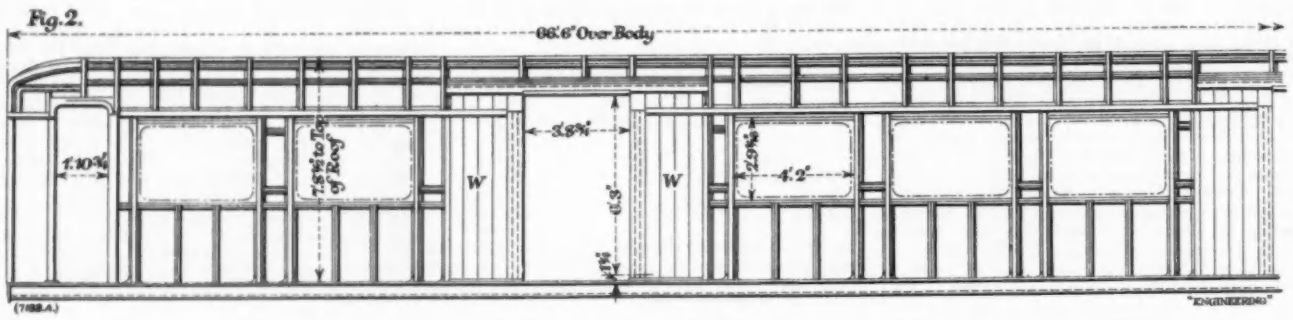
Initial pressure	65 lb. per sq. in.
Back pressure	30 ,, ,,
Total welding pressure, about...	1,200 lb.
Weld tap	No. 5.
Energy relay setting	No. 10.
Back pressure timing	½ sec.
Pressure dwell timing	maximum.

The normal size of the electrode is shown in Fig. 19, on page 172, where it will be noticed that the tip diameter is $\frac{9}{32}$ in., the tip being redressed by machining when it has spread to about ⅜ in. in diameter. The pitching of the spots and the time per spot vary with the nature of the work, but 3 in. pitch and three spots per minute are representative figures.

The body shop is provided with four transformers of 85-kVA capacity. To the transformers are connected 24 welding regulators of the oil-immersed self-cooling type, in circular tanks. The regulators are 20½ in. in height and 16½ in. in diameter, and they weigh 240 lb. They are provided with a main rotary switch and auxiliary switch, so that thirty-six values of current may be obtained from 17 amperes to 210

LIGHTWEIGHT PASSENGER ROLLING STOCK.

Fig. 2.



amperes. The regulators are capable of taking 22 to 4 S.W.G. electrodes. Most of the arc-welding work in the body shop is carried out on the above machines, using a high-grade electrode, generally of 14 S.W.G. Some of the work, however, necessitates carbon-arc welding, for which direct-current welding machines are used. This especially applies to panel joints, etc., where distortion has to be carefully controlled and a neat finish is necessary.

Assembly of Units.—The principal units which are built up on special jigs prior to being assembled into the complete coach are body sides, internal draught screens, driver's and guard's partitions, coach ends, and roof.

The jigs for the body side frames are of substantial construction, the supports having been set in concrete and very carefully lined up and set to the correct height. The plates which carry the clamps for the pillars, etc., are positioned by means of dowels passing through the plate into an angle secured to the inside of the longitudinal of the jig. It is necessary to have some ready means of altering the plates, and the method of using dowels has proved effective. All the clamps have been arranged so that members can be secured in position quickly and so that the final frame can be removed without any difficulty. The principles underlying the side framing jig are illustrated in Fig. 20, on page 172. The clamps are secured to a plate 7 ft. 6 in. by 10 in. by 1 in., with the necessary positioning blocks. The blocks are shown at A and the clamps at B and C. To release the member, screws D are loosened and plate C is then withdrawn. To release clamp B the nut E is loosened, which enables the clamp to be turned. The side-frame jig is arranged so that the resulting framing will have ¾ in. camber. After the jig has been set for the type of car to be produced, the necessary framing members are placed in position and secured by the clamps, after which all the joints are welded by alternating-current electrical arc, using a high-quality electrode, 14 S.W.G. After the framing has been removed from the jig it is treated with a panel wash consisting of phosphoric acid and methylated spirits, and is then ready for spot-welding the side panelling.

The side panels, which are of 16 S.W.G. steel, are marked out to templates from stock sizes, and the necessary joints are welded by means of an automatic carbon-arc welding machine, which has provision for variable and reversible rotation of arc. The carbon-feed motor is mounted on the head, which is fitted with an electrode chuck for carbons 5 mm. by 700 mm. The control set consists of motor, dynamo, and exciter, and also a special direct-current generator for supplying current to the variable-speed driving motor of the welding carriage. All four units are directly coupled and mounted on a channel-iron base. Current is supplied by one portable electric-welding set for 440 volts, three-phase, 50 cycles per second main current, the welding speed being 90 ft. per hour.

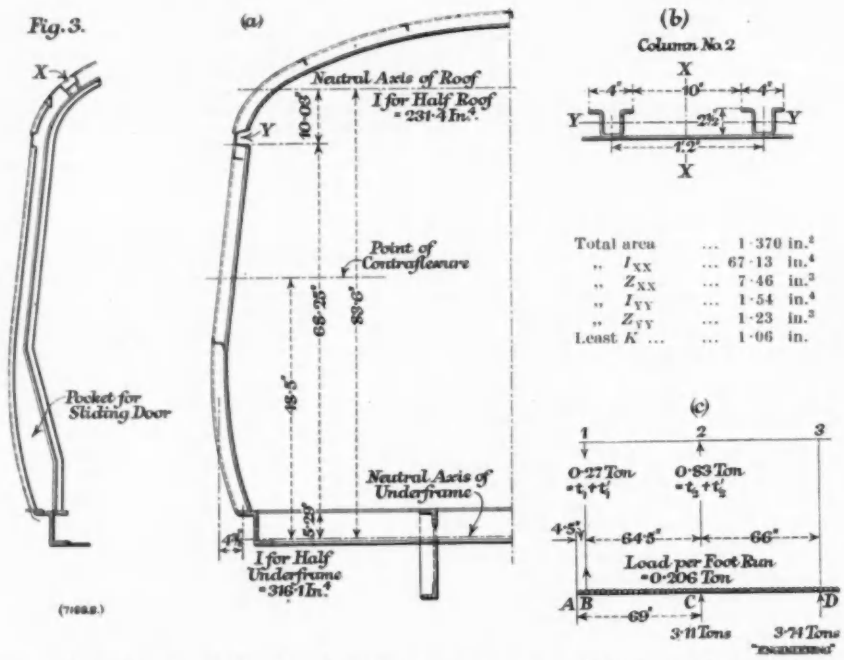
The side panel steel is specified to consist of steel panel sheets, hydraulically flattened, and specially prepared for painting. A typical composition is :—

	Per cent.
Carbon	0·07–0·08
Silicon	Trace
Manganese	0·34–0·39
Sulphur	0·039–0·046
Phosphorus	0·009–0·011

To facilitate the spot welding of the side panels it is necessary that the whole of the panels for the side of the coach be made in one piece.

The full-length side panel is placed on the panel-stretching apparatus, which consists of a movable beam, to one end of which the panel is secured by pins, ¾ in. in diameter, spaced at 3-in. centres. Prior to placing the pins in position, the curved plate is placed on top of the end of the side panel, and holes are drilled through by means of a portable drilling machine. The other end of the side body panel is similarly secured to the fixed end of the panel-stretching device. The beam is tensioned by air cylinders through a lever system. After the panel has been secured at each end, compressed air at 80 lb. per square inch is admitted to the cylinders until the pressure-gauge reading is about 20 lb. per square inch. The side framing, after being treated with "panel wash," is next placed in position on the side framing panel and located by bars in the light openings. The framing panels are now ready for spot welding by means of the portable spot-welding machine. Prior to spot-welding, a primer coating is applied between the framing and the side panels.

Fig. 3.



There are eight draught screens per car, each consisting of two 18 S.W.G. panels, separated by a framing made up of channels, Z-sections, etc. The framing is first assembled on a jig, the members being joined by alternating-current electric-arc welding, using 14-S.W.G. electrodes. It is next lifted clear of the jig, while certain parts, such as partition angles and seat frame, are laid in the jig, so that their flanges are flush with the top. One of the 18-S.W.G. panels is now placed on top of the jig, and the framing is, in turn, placed on top of the panel. The inside of the Z-sections are now spot-welded through the panel to the partition angle below. Certain timber packings are then laid in position, the second panel is placed on top of the framing, and the whole is clamped together on the jig. The final spot welding is completed by a method arrived at after considerable experiment. The problem is to spot-weld the top and bottom panels to each leg of a channel section, and this is done in one operation by inserting a copper bar inside the channel during the setting-up stage, and spot-welding through the bar. The bars are removed later as required. The full-width partitions for driver's and guard's compartments are assembled in a similar manner, but the final welding up was found to give rise to excessive distortion, and ordinary riveting is used at this stage.

The nose end of the motor coaches is built up in sections from panels which have been suitably curved on a panel-stretching machine. For each panel a cast-iron block has been prepared and cleaned on its surface to give the correct contour. The panel plates, previously secured in the jaws of the machine, are stretched over the block, which is gradually raised under hydraulic pressure, as shown in Fig. 15, on Plate IX. The general method of assembling the ends is as already described, except that, since only a relatively small number of motor coaches were to be built, the cost of the jigs was reduced by employing a framework of well-seasoned timber. The curved framing members are built up in subsidiary assembly jigs, and the completed nose-end framing is then placed on trestles to which the curved panel sections are clamped and then spot welded. Fig. 16, Plate IX, shows the jig for the nose end of a motor coach.

The roof is built up into one complete unit before lowering on to the body. It comprises a number of separate galvanised-steel panels with a tensile strength of 28 tons to 32 tons per square inch, and a minimum elongation of 20 per cent. The first operation is to have each panel cut to size, to form a rain gutter on each side, and then to bend it to the correct contour. The gutter is formed on a double-ended folding machine, on which the clamping arrangement is operated by air. In the first stage, the flat sheet has a right-angle bend formed at each end. A resetting of the machine next forms a second right-angle bend, making a channel section. The panel is now passed through hand-operated rollers, 17 in. in diameter, which give the curved shape, and it is finally treated with a wash consisting of 6 gallons of methylated spirits, 3 gallons of tolvol, ½ gallon of spirits of salts, and ½ gallon of carbon tetrachloride.

It is then ready for placing upside down in a roof-section jig, where it is clamped firmly at the gutter. The carlines and purlins, after treatment with panel wash, are placed in position and spot-welded. The time taken to spot-weld an average roof panel is about 30 minutes, which corresponds to about 3½ spots per minute. The galvanising of these roof sheets is found to have a detrimental effect on the copper electrode tips, a difficulty which has not yet been overcome, although cadmium, copper and certain proprietary materials have been tried for these tips. The individual roof panels are now placed in correct position in the roof jig. The pressings over the sliding doors, also the door-head pressings for the guard's door, are placed in position on wooden beams which span the outside longitudinal of the roof jig. When all the sheets,

LIGHTWEIGHT PASSENGER ROLLING STOCK.

Fig.4.

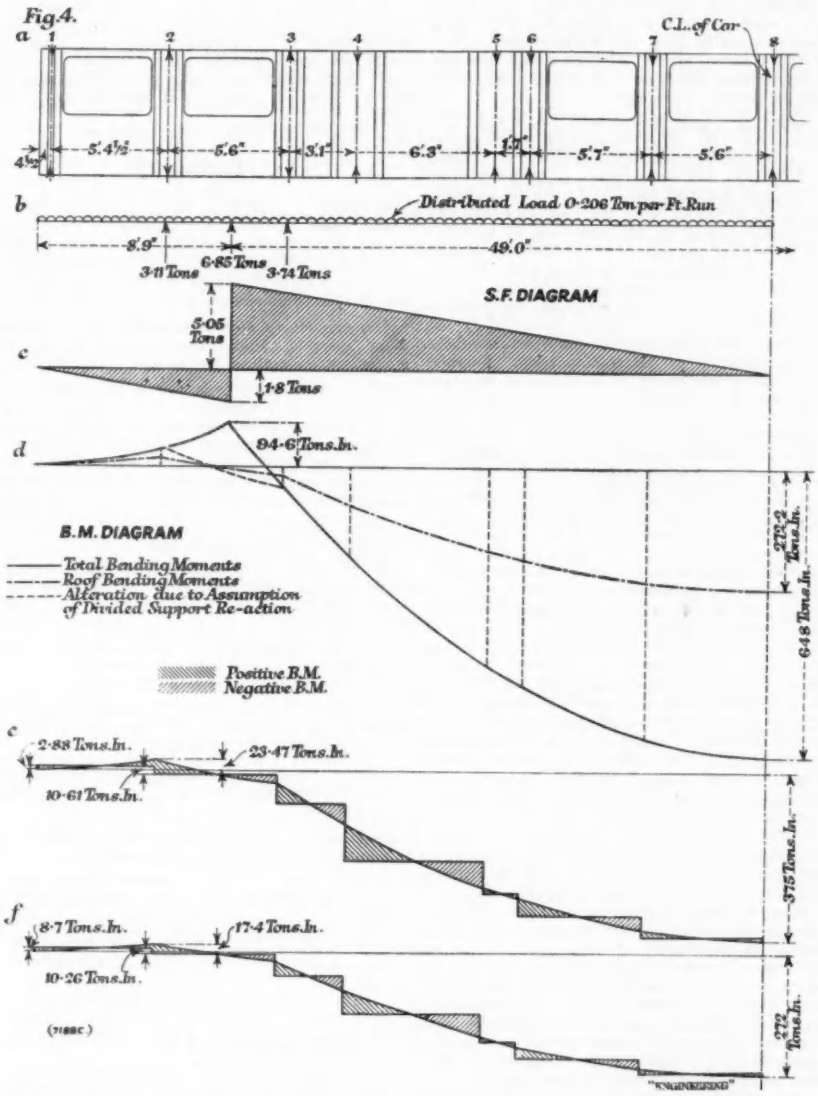


Fig.5.

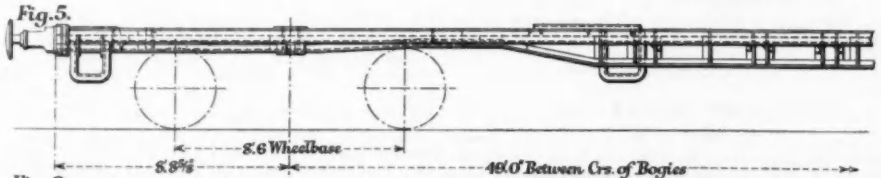


Fig.6.

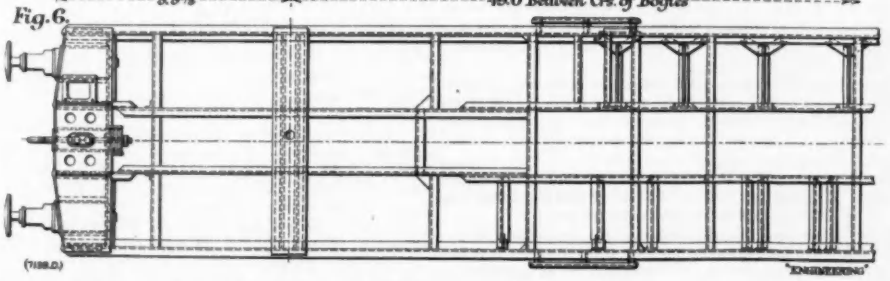


Fig.7.

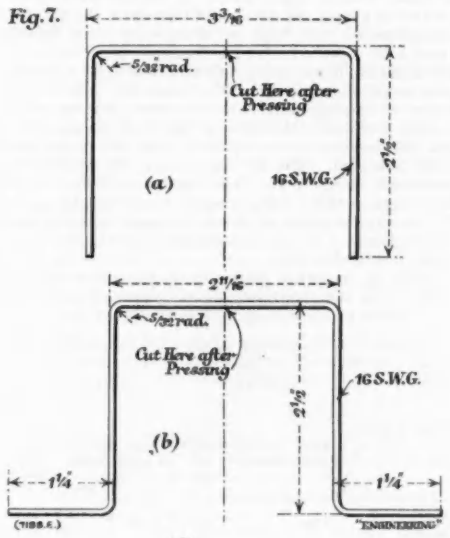
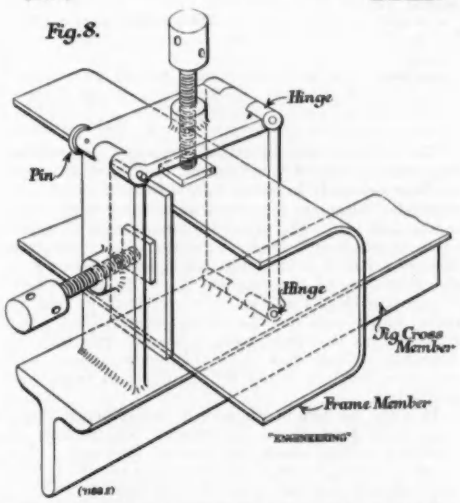


Fig.8.



etc., are in their correct positions, they are clamped to the longitudinal by means of screw clamping channels. To prevent distortion during the electric-arc welding of the joints, steel bands are placed on each side of the roof joint and secured at the gutter. These bands have screws placed at intervals, and are arranged to give a uniform pressure on the sheets. Next, all the roof joints are tack-welded, then the purlin joints underneath and the sheet joints are welded, the work being carried out by eight operators.

It was at first intended to have an automatic machine for welding the roof-sheet joints. On analysis, however, it was found that no saving could be effected. An electric-arc welder can weld 40 ft. per hour and this rate would not be very much improved on by an automatic machine, which also requires one operator to guide it and a large amount of auxiliary equipment for moving it about. All electrodes are of 14 S.W.G. and alternating-current welding is applied.

Erection.—After the side framing has been spot-welded to the body panels, the tension on the panel-stretching apparatus is released and the panel cut at the sliding doorways, thus dividing the side into three portions. These portions are then raised by a lifting beam. The welded underframe is brought from the welding shop on bogies. The floor is concreted on each side of the underframe and across the ends. The underframe is raised with hand screw-jacks, and the trestles are put in positions corresponding to the ends of the solebar, the centre, and points opposite the centre castings. All the trestles are of fixed height, such that the underframe will have a 1-in. camber.

The next operation is to have a longitudinal centre line marked on the underframe, and to mark the positions for the pillars of the sliding doorway. A triangular wooden frame, to which the body side sections are cramped at the cantrail, is then put into position. The bottoms of the pillars are located laterally across the underframe by a cross jig-strap resting on the underframe top, to the ends of which the pillars are fixed by plates and cramps. The correct height to the cantrail is adjusted by small packing plates. The pillar feet and packings are then welded to the solebar. Finally, the whole is braced up by means of temporary diagonal tubular struts, which can be adjusted by means of screws. The driver's and guard's partitions, where required, are placed in position, the joint between the outsides of the partitions and the body pillars being riveted. The coach flat ends are then erected and the pillars welded to the headstock and solebars.

For fitting the roof, the coach is moved by traverser into the appropriate position, the frame being once more set up on trestles to give the required camber. The completed roof is moved over the coach and lowered. It is pulled down into correct position by means of wire ropes and screws. The carline ends are then welded to the cantrail. Draught screens and sliding-door partitions are put in and secured, as well as the galvanised-steel key sheeting for the floor. Where a nose end is required, it is erected at this position. The interior fitting represents the final constructional stage. The finished coach is illustrated in Fig. 17 on page 172.

A loading test was carried out on one of the first motor cars to be completed. The body and underframe unit were set up on jacks placed under the solebars at the bogie centre lines. Measurements of unloaded cambers were first made, and centre marks

were made on partitions and door-pocket pillars so that any variations in door-pocket width could be measured. The coach was then loaded with 13,720 lb. of brake blocks, representing 88 seated passengers, a driver, a guard, and 10 cwt. of luggage in the guard's compartment, and fresh measurements were taken. These were repeated after the load had been increased by 12,320 lb., representing a further load of 88 standing passengers, and again after the coach had been drawn across a crossing and back to assist the frame to "settle." Finally, the whole of the load was removed, and the measurements repeated with the frame and body unloaded. The permanent set was slight, the maximum being $\frac{1}{16}$ in. The maximum deflection of the solebars under 100-per cent. overload was $\frac{5}{16}$ in. The transverse width of the door-pocket openings was also carefully watched, but no greater variation than $\frac{1}{16}$ in. occurred in this.

Table II, herewith, gives the weights of motor and trailer cars, compared with the two previous types of stock in use on the Liverpool and Southport line.

TABLE II.—*Weights of Motor and Trailer Cars.*

Type of Stock.	Motor Cars.			Trailer Cars.		
	Tare Weight.	No. of Seats.	Tare Weight per Seat.	Tare Weight.	No. of Seats.	Tare Weight per Seat.
	Tons.		Lb.	Tons.		Lb.
Original 10 ft.-wide stock	47·25	83	1,275	24·75	103	538
Euston - Watford type, compartment stock	53·0	84	1,415	28·0	92	682
New all-steel welded stock	40·5	88	1,030	23·2	102	510

The vehicles last described represent the latest stage in a process of development, the object of which has been primarily to reduce weight without sacrifice of strength. Although applied to suburban rolling stock in the first place, the principles appear equally applicable to main-line stock, but after each new step forward a period of consolidation is desirable in which the behaviour of the vehicles in service is watched. It is impossible at this stage to say anything on relative costs, which were not the prime consideration. For pioneer work on a small scale, it has not been thought desirable to introduce more elaborate presses and machines, such as would be justifiable in large-scale production.

It is the practice in England to endeavour to apply each step forward in lightweight construction to standard rolling stock for general purposes. The special lightweight train built for some specific service is practically unknown. As public demand for comfort in travel is always on the increase, it is possible that the bottom of the curve of total weight per passenger has been reached, but for operating economy it is desirable, if possible, to avoid any upward trend in tare weights. The bogie, in general, still follows conventional design, and the possibilities of a complete breakaway in fundamental outline cannot be ignored. The body and underframe are already merging one into the other suggesting a modified form of tube as a further line of development. The wheel and axle assembly has been slow to yield material weight saving, the impacts from rail joints limiting progress in this respect. The elimination of the solid axle, and independently sprung wheels, while bristling with difficulties, are at least a line of attack. Finally, brake gear, with its separate cylinders and rigging, may give place to cylinders integral with the structure of the bogie frame, resulting in the practical elimination of brake gear as such. First steps in all these directions have been taken in different parts of the world, and although not all equally or immediately successful, they do open up a field for further improvements.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—The 22nd annual dinner of the Institution of Locomotive Engineers will be held on Wednesday, February 28, at 6.30 for 7 p.m., at the Savoy Hotel, London, W.C.2.

CALENDAR.—Messrs. A. A. Jones and Shipman, Limited, New Century Works, East Park-road, Leicester, have sent us a monthly tear-off calendar on each sheet of which the previous and succeeding months are exhibited as well as the current month.

WATER-POLLUTION RESEARCH LABORATORY.—We are informed that the central offices and laboratories of the Water-Pollution Research Board have been transferred to Langley-road, Watford, Herts. They will remain there during the war and until the research station specially designed for the work can be built.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 2*d.* including postage.

Wire Ropes for Lifts and Hoists.—A revision of Specification No. 329, which deals with round-strand steel-wire ropes for lifts and hoists, and was first issued in May, 1928, has now been issued. The publication provides for round-strand ropes of Lang's or ordinary lay of 6 by 12, and fibre, 6 by 19, 6 by 19 Seale, and 6 by 24 constructions, for use with cage or platform hoists or lifts—for passengers or goods—working in guides. It is not intended to apply to ropes for coal hoists or similar lifting appliances. In the revised specification wire having an ultimate tensile-stress value below 80 tons to 90 tons per square inch has been eliminated, and bend tests on the wires have been included, in addition to the torsion tests. Furthermore, the sizes of the ropes are now limited to ropes having circumferences from $\frac{3}{4}$ in. to $1\frac{3}{4}$ in. The foreword of the specification has been considerably amplified, and modifications have been made to the recommended sizes of drums, sheaves and diverter pulleys.

Commercial Testing of Small Steam-Raising Plants.—A British Standard Code for Comparative Commercial Tests of Coal or Coke and Appliances in Small Steam-Raising Plants has now been issued. It will be recalled that a British Standard Code for Commercial Acceptance Tests for Steam Boilers (No. 845-1939) was issued last summer and commented on in our columns on page 227 of vol. 148 (1939). Briefly, this provides for the determination, under commercial conditions, of the efficiency of steam boilers and is intended for use in establishing whether or not guarantees agreed to between the purchaser and the vendor have been fulfilled. A Code of this type would probably be too comprehensive for use by small steam users in their own works for the determination of the relative values of different fuels or for assessing the value of new equipment. Having regard to the desirability of encouraging such steam users to carry out evaporation tests, the present special abridged Code, designated No. 878-1939, has been prepared, in the hope that it will assist them to make such tests on the evaporation and fuel consumption of their plant as will ensure that they are securing the best possible results from the fuel or appliances purchased. The new Code provides for the carrying out of tests to determine the relative value of different solid fuels and/or the relative values of new equipment, such as grates, circulators, air heaters, smoke eliminators, and other auxiliary boiler apparatus, in small steam-raising plants under ordinary working conditions. The Code has been prepared in such a manner as to render an analysis of the fuel or of the flue gases not essential. Provision for dealing with these matters has, however, been made in an appendix and it is recommended that, wherever possible, this additional information should be obtained.

BOOKS RECEIVED.

The Engineer's Year-Book of Formulæ, Rules, Tables, Data and Memoranda for 1940. Originally compiled by H. R. KEMPE and W. HANNEFORD-SMITH. 46th annual issue. Revised under the direction of L. ST. L. PENDRED. London: Morgan Brothers (Publishers), Ltd. [Price 31*s.* 6*d.* net.]

Department of Scientific and Industrial Research. Report of the Road Research Board for the Year Ended 31st March, 1939. *With the Report of the Director of Road Research.* London: H.M. Stationery Office. [Price 3*s.* 6*d.* net.]

Ministry of Health. Local Government Financial Statistics. England and Wales. 1936-37. Part III. London: H.M. Stationery Office. [Price 1*s.* 3*d.* net.]

South Australia. Annual Report of the South Australian Railways Commissioner for the Year 1938-39. Adelaide; South Australia: Government Printing Office.

Technische Dynamik. By PROFESSORS C. B. BIEZENO and R. GRAMMEL. Berlin: Julius Springer.

United States Department of the Interior. Bureau of Mines. Minerals Yearbook, 1939. Compiled under the Supervision of H. H. HUGHES. Washington: Superintendent of Documents. [Price 2 dols.]

Statistical Method from the Viewpoint of Quality Control. By DR. W. A. SHEWHART, with the editorial assistance of DR. W. E. DEMING. Washington: Graduate School, Department of Agriculture.

Department of Scientific and Industrial Research. Water Pollution Research. Summary of Current Literature. Volume III. No. 1. *January,* 1940. Abstracts Nos. 1 to 137. London: H.M. Stationery Office. [Price 2*s.* net.]

PERSONAL.

MR. ARNO PENKUHN has acquired the sole manufacturing and sales rights of Artus milling-cutter spacers for Great Britain and the British Empire, except Canada. A description of these spacers, which are made of synthetic resin and are supplied in thicknesses ranging from 0·001 in. to 0·007 in., each having a distinctive colour, will be found on page 517 of ENGINEERING, vol. 146 (1938).

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Primary-Battery Materials, including zinc and ammonium chloride. Posts and Telegraphs Department, Melbourne, Australia; March 12. (T. 15,274/40.)

Overhead Travelling Crane, 40-ton, for indoor operation in the substation workshop, Mount Roskill, Auckland. To be used for the lifting and transport of 10,000-kVA. single-phase transformers and other apparatus. The hoisting and traverse motions to be operated by electric motor controlled from floor level. Public Works Department, Wellington, N.Z.; March 5. (T. 15,643/40.)

Wheels and Axles.—With reference to the call for tenders for rolling-stock wheels and axles, noted on page 36, *ante,* we now learn that the South African Railways and Harbours, Johannesburg, have extended the closing date for the receipt of tenders until March 11. (T. 30,398/39.)

Metering Equipment of various types. Electricity Department, City of Salisbury, Southern Rhodesia; March 18. (T. 16,031/40.)

Secondary Cells, assembled, or, alternatively, unassembled. Post and Telegraph Department, Wellington, N.Z.; March 27. (T. 16,062/40.)

Railway Couplings, screw-type. Indian Stores Department, Engineering Branch, New Delhi; March 6. (T. 16,077/40.)

Steel Plate. South African Railways and Harbours, Johannesburg; March 26. (T. 16,083/40.)

Grinding Wheels. South African Railways and Harbours, Johannesburg; March 14. (T. 16,087/40.)

Electric Power Station, for lighting load and distribution network. Municipality of Pearston, Cape Province, South Africa; March 20. (T. 16,095/40.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—During the past week operators on the Welsh steam-coal market were faced with considerable difficulty in arranging new business, particularly for early delivery. As a result of recent stoppages, producers were concentrating upon fulfilling orders already on their books, and in making good arrears of deliveries. There has been some accumulation of orders, so that offers of coal for shipment were restricted. The demand failed to show any falling off, however, and the tone was consequently still very firm. The decision of the South Wales miners to reject the owners' offer for a national wage increase caused some surprise locally, where it had been expected that they would follow the recommendation made by the executive council of the Miners' Federation and accept them. South Wales was the only large coalfield, with the exception of Scotland, to reject the proposals, which were accepted at the national conference. The proposals provide for a wage increase of 5*d.* per shift for adult workers and 2½*d.* per shift for youths, to be made retrospective to January last. Adult miners' wages have thus been increased by 1*s.* 1*d.* a shift, or 6*s.* 6*d.* per week, from the pre-war level, which represents an additional 1,500,000*l.* on the wage bill for the coalfield. There was a keen demand for the popular duff classes. Supplies of these sorts remained extremely scarce and sellers had very little to offer over some months ahead. As a result, any occasional odd parcels that became available were quickly taken up at high figures. A firm tone ruled for the sized and large qualities, which were being steadily absorbed. Smalls were in limited supply. Cokes were in request, but scarce, while patent fuel remained active.

The Iron and Steel Trade.—Busy conditions were again maintained in the iron and steel and allied trades of South Wales and Monmouthshire. The demand for finished products was continued, and orders were booked for delivery over long periods ahead. The works remained engaged almost to full capacity and stem lists were well filled.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Inquiries show that outputs of many types of products could be increased if more men were available to operate machines. Efforts are being made by firms in various parts of the country to attract engineers from the Sheffield district. The wages paid here are up to the standard of those obtaining in similar areas. Among the men in urgent demand are press-tool fitters, turners, jig and tool fitters, and machinists generally. Pronounced activity marks all sections of local industry. Furnaces are operating to capacity, turning out record tonnages of steel. Government requirements are on the increase, while ordinary commercial needs have been maintained at a consistent level. Producing works have entered into forward commitments for the supply of pig iron, hematites, and scrap. So far little difficulty has been experienced in obtaining the necessary supplies. Ferro-alloys are in strong demand, and Sheffield works are consuming record tonnages of ferro-chromium, ferro-manganese, ferro-tungsten, and ferro-silicon. Reports from the heavy-machinery and engineering branches indicate that the influx of orders has gained further strength. Government requirements dominate the position, though many works contrive to do an increasing amount of commercial business on both home and overseas account. This applies particularly to grinding and crushing machinery, coal-breaking machines, and cement-making equipment. Greatly increased tonnages of shipbuilding steel, forgings, castings, tools, and ship furnishings are leaving this area for shipyards in various parts of the country. The agricultural-engineering section is having a busy time. Order books have been augmented during the past few weeks. Farmers not only in this country, but also abroad, are receiving better prices for their products, and are overhauling their equipment. New machines are in demand, while more repair work is circulating. Active conditions prevail in the production of all types of electrical plant. There is a big demand for electric motors, and plant for generating stations. Many works specialising in the production of engineers' small tools are now operating 24 hours a day. The file market is developing on progressive lines. Overseas needs are more substantial, while shipments to Italy and Spain are reported to be on the increase.

South Yorkshire Coal Trade.—Bigger tonnages are available for industrial concerns, and wagons are moving more freely from neighbouring collieries. Small coal is in demand by electricity works. The house coal market is active, and merchants are steadily reducing arrears of orders. There is a brisk call for most types of cokes. The export position shows a slight improvement.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The great activity which has prevailed in the Scottish steel works during past weeks shows no signs of slackening, and full production is general. This is very necessary because of the steady and urgent demand for steel material of all descriptions. Shipbuilders, boiler makers, erectors, drum and other container makers all keep pressing for deliveries in order to overtake orders on hand. A large percentage of the bookings are against Government contracts, and outside the demand for home purposes, export orders are receiving very favourable consideration. In the black-steel sheet branch of the industry active conditions are general, and producers have as much work booked as ensures steady running for some time ahead. The supply of raw materials is quite satisfactory at present, and although scrap steel is none too plentiful, the requirements of consumers are not being overlooked and there is not much fear of a shortage. The inquiry from overseas buyers represents a very large tonnage of material of a general character, but owing to the necessity at the present time of meeting the ever-increasing demands of the home market, only a small percentage of this business is being accepted. The advance in prices which was referred to last week has been taken philosophically by buyers and although some have not been pleased, the increase was generally anticipated. The following are the current quotations:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, under $\frac{3}{16}$ in. thick, weighing 6 lb. or more, per square foot, 14*l.* per ton; weighing less than 6 lb. but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton.

Malleable-Iron Trade.—Conditions in the malleable-iron trade of the West of Scotland show little change and with quite a fair amount of work booked most plants are well employed. The re-rollers of steel bars are fully occupied as they have a large tonnage on order and fresh business is subject to negotiation as to probable date of delivery. The raw material position is better, and the forward outlook is more satisfactory. The current prices are as follows:—Crown bars, 12*l.* 17*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; re-rolled steel bars, in 4-ton lots, 14*l.* 3*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There is still a very heavy demand for Scottish pig-iron and the present output is going rapidly into consumption. All consumers are requiring large tonnages to keep up with production, and many urgent calls are being received from buyers for deliveries ex-contract. Foundry grades alone are not too active, but the outlook is better. To-day's market prices are as follows:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The demand for iron and steel is unabated and buyers readily pay the recently advanced prices for commodities. Government requirements still absorb the bulk of the supply, but some slight increase in the tonnage available for civil needs is reported and it is believed that a gradual expansion in commercial trade is likely. Careful supervision of distribution is necessary, however, to avoid shortage of essential deliveries.

Cleveland Iron Trade.—There is little prospect of a material increase in the supply of Cleveland pig, the output of which is still suspended. The intermittent make of Tees-side iron suitable for founders' needs is meagre, but deliveries of Midland products are regular and are on a scale that covers requirements. The fixed prices of Cleveland pig are ruled by No. 3 quality at 111*s.*, delivered within the Tees-side zone, and this is still considerably below the figures named for odd lots of Continental iron offered here, for which there is virtually no demand.

Hematite.—Pressure for the delivery of East Coast hematite is heavy and producers are so extensively committed that they are not disposed to discuss new business. Second hands have command of little iron and are only distributing the tonnage available cautiously among customers of long standing. The large output is well maintained, but falls short of current needs and tonnage accumulations at the blast furnaces have decreased to levels as low as is desirable. Buyers are insisting on full contract deliveries and are anxious to negotiate for forward supplies. The parcels they are receiving are substantial, but most of the make continues to pass into use at the producers' own consuming departments. The statistical position calls for careful attention, but confidence is expressed in the ability to cover the consumers' requirements for a long time. The stabilised quotations are based on No. 1 grade of hematite at 127*s.* 6*d.*, delivered to North of England areas.

Basic Iron.—There is no saleable basic iron, the increased make being needed for the producers' own steelworks. The quotation of 104*s.* 6*d.* is nominal.

Foreign Ore.—There is no shortage of foreign ore. Users have fairly substantial quantities on hand and imports are coming forward satisfactorily.

Blast-Furnace Coke.—Business in Durham blast-furnace coke matures only slowly. Local consumers are extensively covered and holders are not pressing sales. The fixed price of good medium qualities is 31*s.* 8*d.* at the ovens.

Manufactured Iron and Steel.—Semi-finished and finished iron and steel firms continue to be actively employed. The make of semies has been further increased and imports of Continental semies continues on a substantial scale. Finished-iron manufacturers are turning out heavy tonnages and finished-steel producers have still to run their plants at full capacity to cope with customers' requirements. Pressure for the delivery of heavy steel is being met by some addition to output, and the demand for shipbuilding material is being supplied better than was anticipated would be the case. Sheet makers are very busy on ordinary industrial orders, but even at the advanced price of 20*l.* for galvanised corrugated sheets, producers are experiencing difficulty in keeping pace with market requirements.

Scrap.—The available parcels of iron and steel scrap are readily purchased at the control prices.

RE-OPENING OF THE MORDEN-EDGWARE LINE.—It was announced in Parliament last week that the section of the Morden-Edgware line between London Bridge and the Bank, which has been closed since the outbreak of war to enable certain protective works to be carried out, will be re-opened about the middle of May.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

ROYAL INSTITUTION.—To-night, 5 p.m., 21, Albemarle-street, W.1. "Physics in War Time," by Professor Sir William Bragg. Tuesday, February 20, 3 p.m., "Present-Day Study of the Stars," by Professor Sir James Jeans. Wednesday, February 21, 5.15 p.m., "X-Ray Optics," by Professor W. L. Bragg. Thursday, February 22, 3 p.m., "Measurement of Gravity," by Dr. A. O. Rankine.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—*Student Section:* To-night, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "Electrical Measurement of Mechanical Quantities," by Mr. W. W. Campbell. *Institution:* Thursday, February 22, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Creep at High Temperatures," by Mr. J. H. Tapsell.

BRADFORD ENGINEERING SOCIETY.—To-night, 7.30 p.m., The Technical College, Great Horton-road, Bradford. "The Development of High-Speed Craft and Its Machinery," by Mr. F. C. Bishop.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North Midland Centre:* Saturday, February 17, 2 p.m., The Hotel Metropole, King-street, Leeds. "Operating Experience with High-Voltage Alternators," by Mr. W. D. Horsley. *Mersey and North Wales (Liverpool) Centre:* Monday, February 19, 6.15 p.m., Liverpool Royal Institution, Colquitt-street, Liverpool. Joint Meeting with THE LIVERPOOL ENGINEERING SOCIETY. (i) "Statistics and Engineering Practice," by Dr. B. P. Dudding and Mr. W. J. Jennett. (ii) "Statistical Methods and Factors of Safety," by Mr. W. T. O'Deal *North-Western Centre:* Tuesday, February 20, 6.45 p.m., The Engineers' Club, Manchester. "Storage Batteries," by Mr. E. C. McKinnon. *Institution:* Thursday, February 22, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. "Insulation Stresses in Transformers" (with demonstration), by Mr. H. L. Thomas.

INSTITUTION OF MECHANICAL ENGINEERS.—*Yorkshire Branch:* Saturday, February 17, 2.30 p.m., The University, St. George's-square, Sheffield. Thomas Hawksley Lecture, by Sir Leonard Pearce.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Saturday, February 17, 2.30 p.m., The James Watt Institute, Birmingham. "Practical Applications of Temperature Control and Measurement," by Mr. W. M. Barratt. *North-Western Section:* Monday, February 19, 7.30 p.m., Engineers' Club, Manchester. Chairman's Address, by Mr. G. L. Wollaston. *Institution:* Friday, February 23, 6.30 p.m., 39, Victoria-street, Westminster S.W.1. Lecture: "The Application of Steam Propulsion to Road Vehicles," by Mr. M. H. Lewis.

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Midlands Branch:* Saturday, February 17, 2.30 p.m., The Technical College, Derby. "Grey Iron Problems," by Mr. B. Hird.

INSTITUTION OF CIVIL ENGINEERS.—*Yorkshire Association:* Saturday, February 17, 2.30 p.m., The Grand Hotel, Sheffield. "Modern Motor Roads," by Professor J. Husband. *Institution:* Tuesday, February 20, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Dragline Excavator," by Mr. W. Barnes. *North-Western Association:* Wednesday, February 21, 6.15 p.m., 36, George-street, Manchester. Lecture: "Uses of Gunite," by Mr. T. W. Moran.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*Glasgow Centre:* Monday, February 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Gas as a Fuel for Motor Vehicles," by Dr. J. S. Clark. *Leeds Centre:* Wednesday, February 21, 6 p.m., Metropole Hotel, Leeds. "Some Problems We Meet," by Mr. H. L. Dawtrey.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, February 20, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Welding as a Substitute for Casting," by Dr. S. F. Dorey.

IRON AND STEEL INSTITUTE.—Tuesday, February 20, 7.30 p.m., Grand Hotel, Sheffield. Joint Meeting with THE SHEFFIELD METALLURGICAL ASSOCIATION. (i) "Oxygen Determinations on a Series of Bath Samples Taken from an Acid Open-Hearth Furnace," by Dr. G. E. A. Bramley, Dr. W. R. Maddocks and Mr. G. Tateson. (ii) "Torsional Overstrain in Mild Steel," by Professor H. W. Swift. (iii) "Nickel-Chromium-Molybdenum-Vanadium Steel," by Dr. W. H. Hatfield.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Wednesday, February 21, 7 p.m., E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Modern Lighting Practice and A.R.P. Requirements," by Mr. R. Pelerin.

INSTITUTE OF FUEL.—Thursday, February 22, 2.15 p.m., The Geological Society's Rooms, Burlington House, W.1. "Modern Gas Storage," by Mr. Stanley Thomson.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, February 23, 7.15 p.m., Engineers' Club, Manchester. "Development in Design of Boilers and Boiler House Auxiliaries," by Mr. A. Pollitt.

LIGHTWEIGHT PASSENGER ROLLING STOCK.

(*For Description, see Page* 165.)

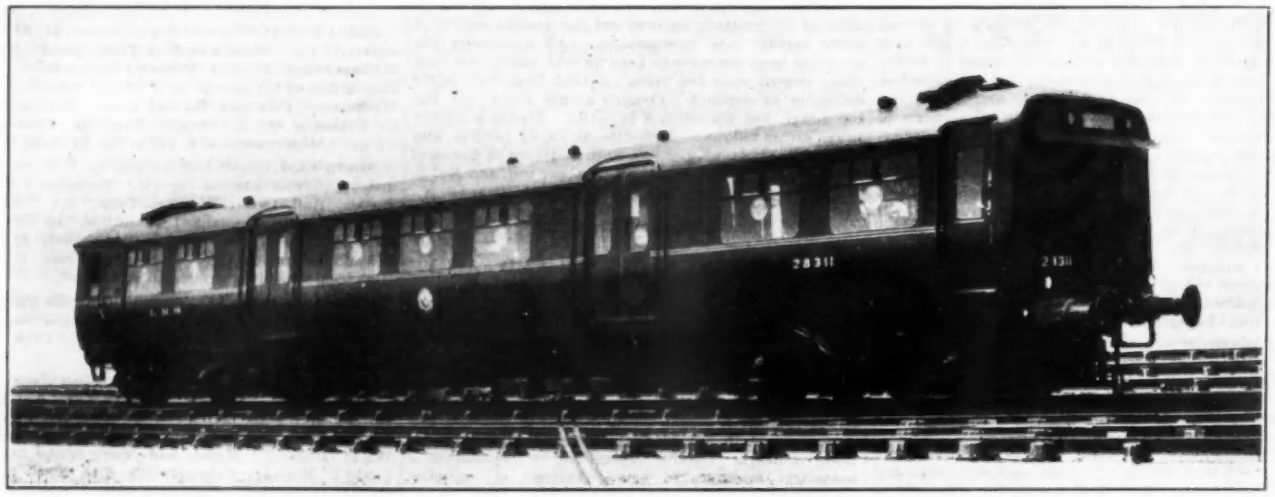


Fig. 17. Finished Motor Coach.

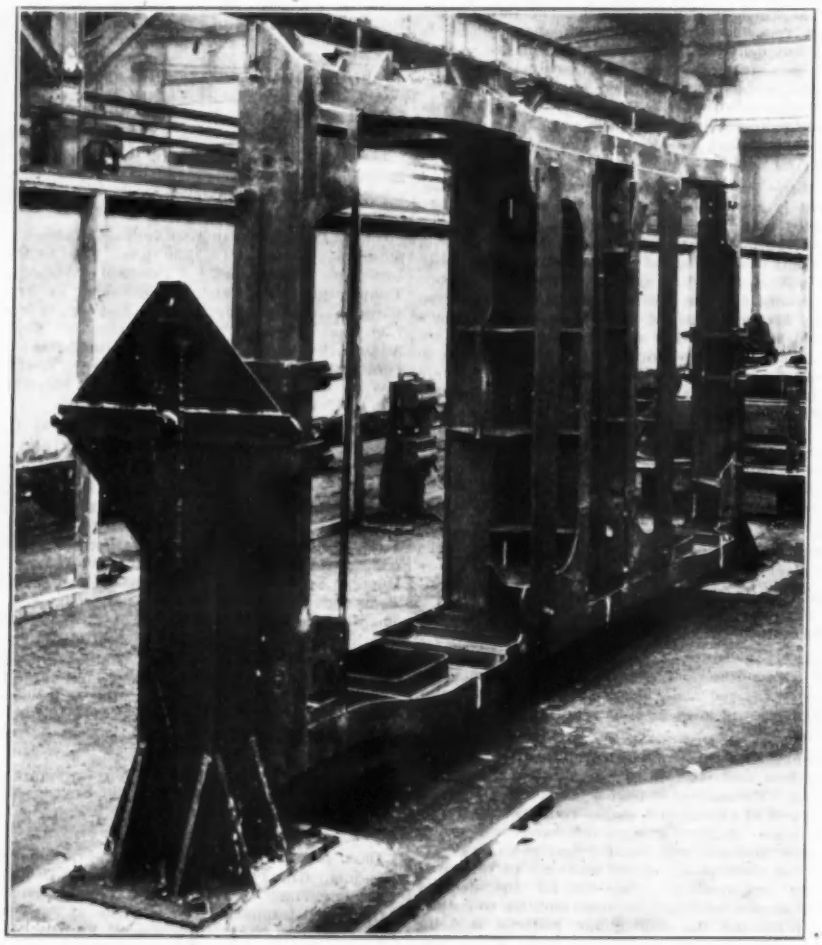


Fig. 18. Bogie Mounted in Trunnions for Final Welding.

Nickel-Clad Steel.—A publication issued by Messrs. The Mond Nickel Company, Limited, Thames House, Millbank, London, S.W.1, contains data regarding the properties and fabrication of nickel-clad steel. It is stated that, at the high temperatures employed for the hot-rolling of the pure nickel sheet on to the steel, the nickel and the steel form solid solutions at the plane of contact, thus ensuring a firm and permanent bond. Tests on the strength of the bond between the two materials show that it is more than 24·8 tons per square inch; in other words, that the strength is higher than that of the steel base. As is to be expected, the nickel covering is resistant to the same extent as solid nickel, to attack by many corrosive agents. It is pointed out that, in the fabrication of nickel-clad steel, only slight modifications from steel-fabricating practice are required.

Road Construction in Turkey.—When the Turkish Republic came into being there were in existence in the country 13,885 km. of roads and 4,450 km. of tracks. According to a recent issue of the *Monthly Trade Journal* of the British Chamber of Commerce of Turkey, the aggregate length of the highways is now 45,565 km. Furthermore, extensions are being continued year by year; thus, in 1938, new roads totalling 356 km. were constructed and 531 km. of highways and 878 bridges were repaired. In addition, the building of the road, 642 km. in length, between Trebizond and the Iran frontier, for the transit trade between the two countries, is being actively pushed forward.

Fig. 19.

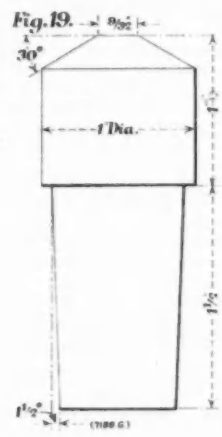
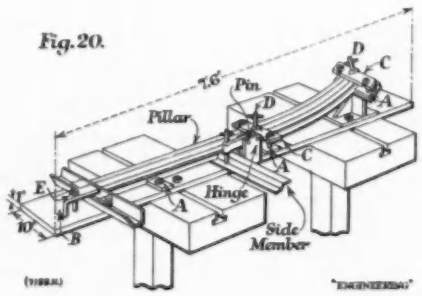


Fig. 20.



Chemical Analysis of Aluminium and Its Alloys.—Since the publication, some time ago, by Messrs. The British Aluminium Company, Limited, Raven Hotel, Castle-street, Shrewsbury, Salop, of a treatise entitled *Chemical Analysis of Aluminium and Its Alloys*, additional methods of analysis have been developed and standardised in the laboratories of the company. These have been dealt with in a brochure which has been designed so that it may be fitted into the backs of existing copies of the publication. The new brochure contains additional methods for the determination of antimony, bismuth, niobium and zinc in aluminium alloys, and methods for the analysis of "super-purity" (99·990 per cent. to 99·998 per cent.) aluminium, of aluminium bronze, and aluminium skimmings and dross. In all cases the principles involved and the reagents required are given, as well as the actual manipulations and limits of error of the method.

LIGHTWEIGHT PASSENGER ROLLING STOCK ON THE L.M.S. RAILWAY.

MR. W. A. STANIER, M.I.MECH.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see Page* 165.)

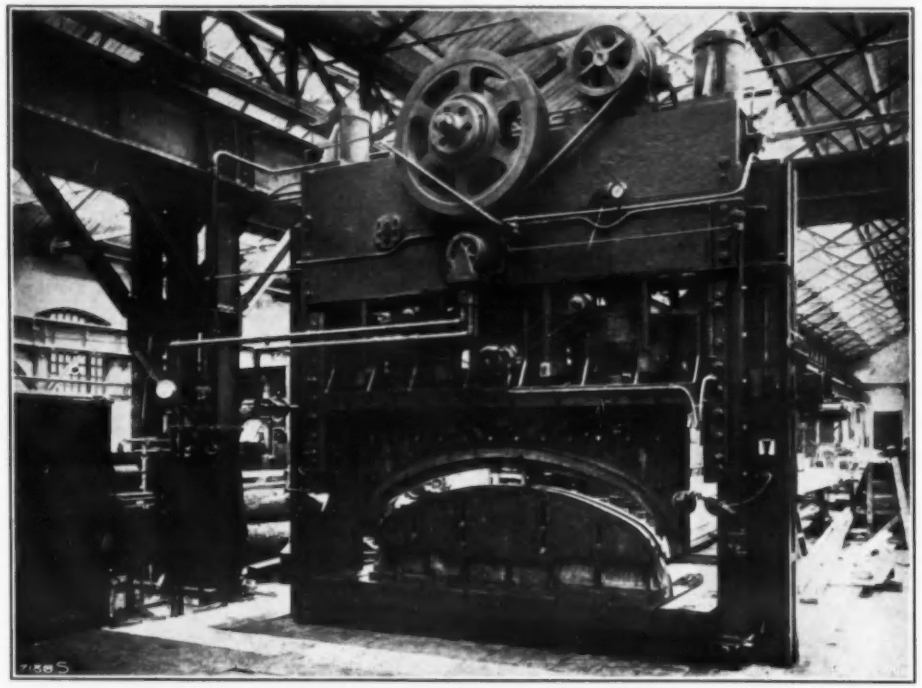


FIG. 9. CARLINE TOOLS IN 300-TON PRESS.

FIG. 10. NIBBLING PRESS CUTTING CARLINE PRESSINGS.

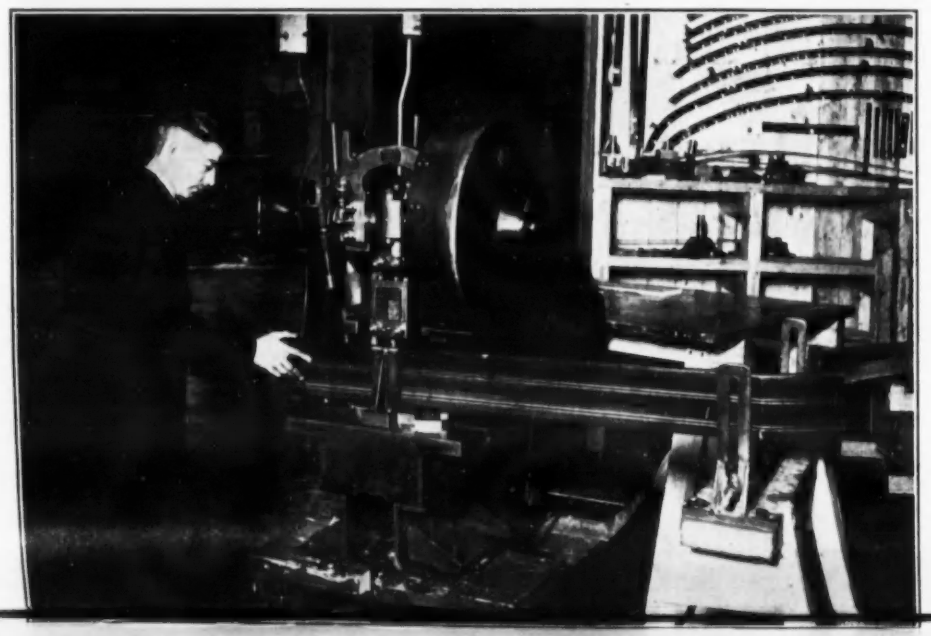


FIG. 11. PILLAR IN TRIMMING PRESS.

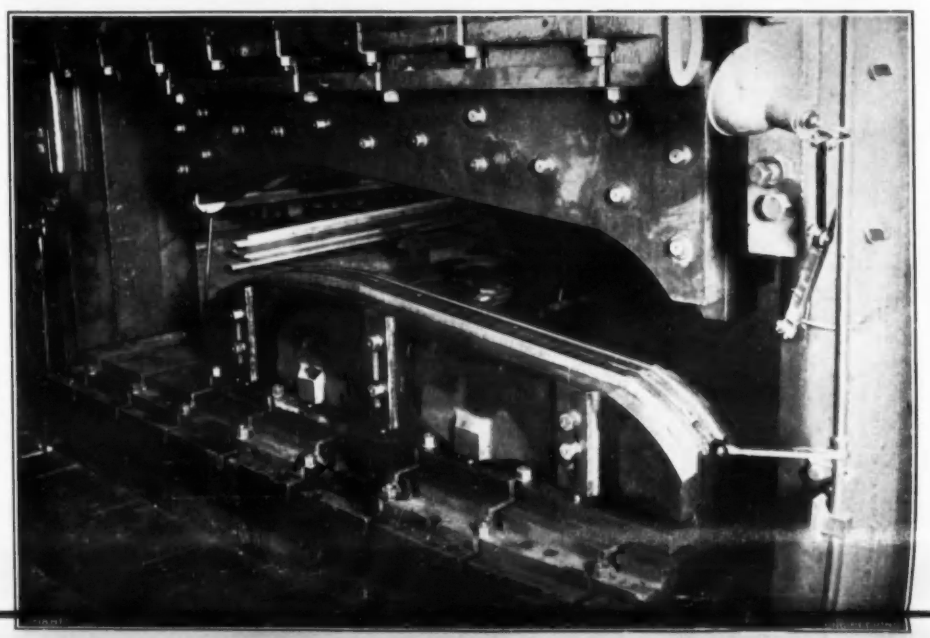


FIG. 12. FINAL OPERATION ON PILLAR IN 300-TON PRESS.

Fig. 11. Pillar in Trimming Press.

Fig. 12. Final Operation on Pillar in 300-Ton Press.

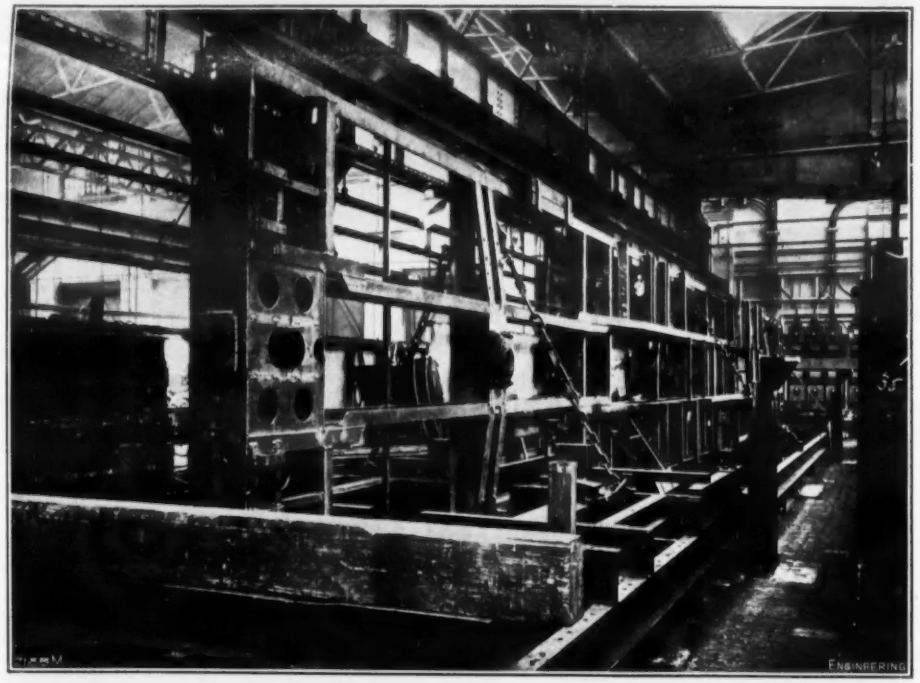


Fig. 13. Underframe on Side for Final Welding.

Fig. 14. Welded Cross-Member for Motor Bogie.

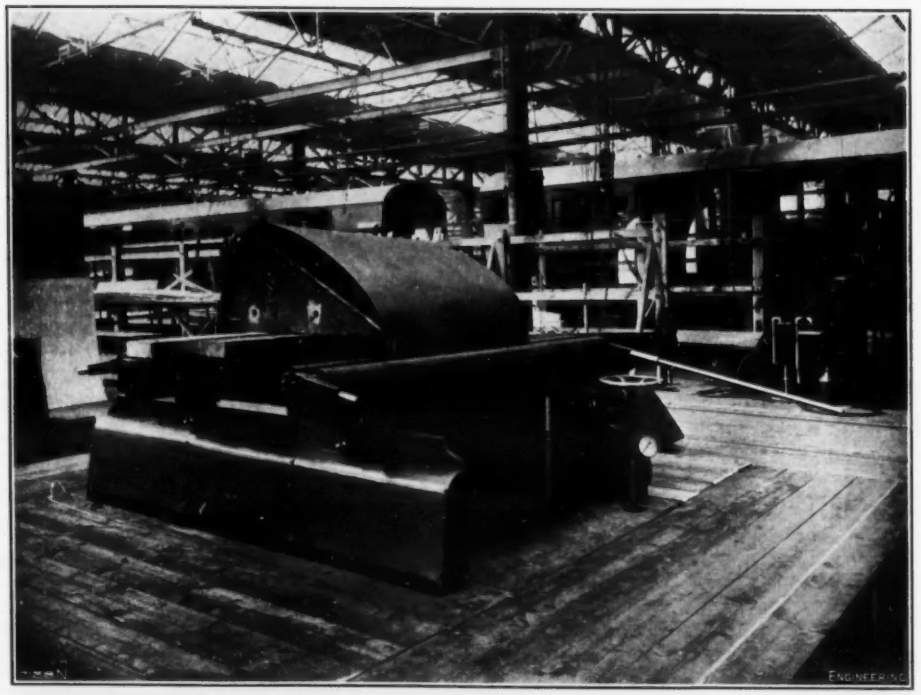


Fig. 15. Panel-Stretching Machine.

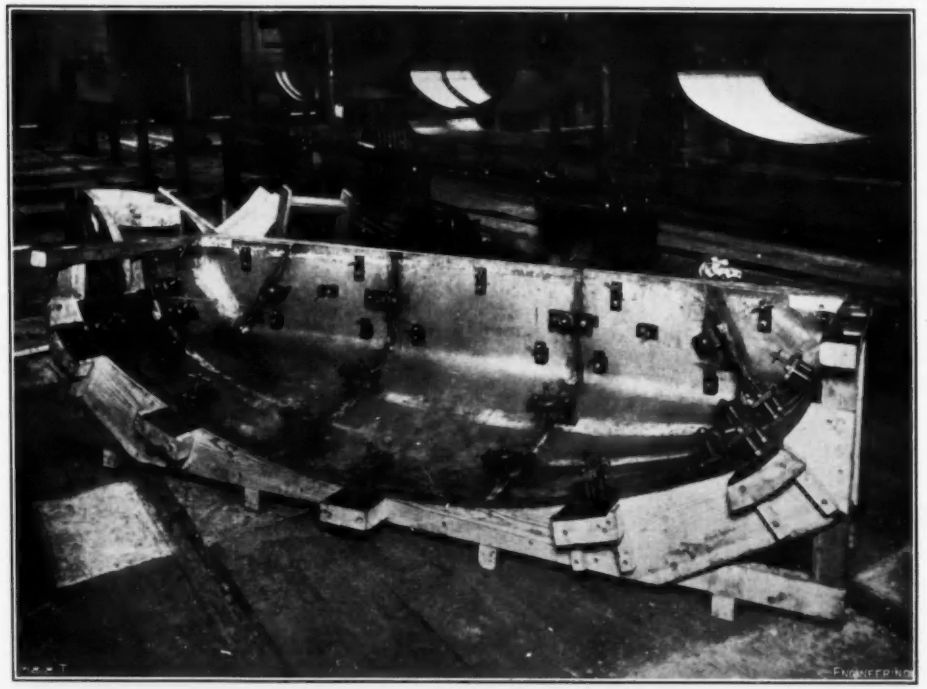


Fig. 16. Jig for Nose End of Motor Coach.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of Publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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THE EMERGENCY PORTABLE GAS PRODUCER.

WHEN commenting, in November last,* on the removal of the major disabilities suffered by operators of road vehicles using producer gas, we referred to the fact that the committee set up by the Government to study the emergency conversion of motor vehicles to producer gas had recommended a design of producer based on their own investigations. This design was offered without restrictions to any firm willing and able to undertake its manufacture; and we remarked, at the time, that this action on the part of the Government appeared manifestly unjust to those firms who had devoted much time and money to establishing the portable producer on a commercial basis in the face of past official interference, not to say discouragement. The report† of the committee referred to has now been issued, and we regret to note that, not only has this point not been touched upon, but only the scantiest credit is given to those pioneer firms whose work made the committee's design possible.

The committee, under the chairmanship of Sir Harold Hartley, was set up in May, 1937, at the special request of Sir Thomas Inskip, Minister for the Co-ordination of Defence, to investigate the scope of producer gas as an alternative fuel to petrol for commercial and passenger-service vehicles, with particular reference to the consideraton of the means by which (in the event of an emergency) such vehicles could be quickly and cheaply adapted to the use of gas. As we have previously pointed out, it is very generally recognised that the best results can only be secured from producer-gas driven vehicles if the vehicle and producer plant are designed *ab initio* as one unit. In view of this fact, it should be stressed, perhaps, that the committee entirely limited their attention to a consideration of the scope of producers for the propulsion of road vehicles in an emergency. While the distinction between vehicles specially designed for producer-gas operation and those which have been merely converted to run on gas may not appear of much importance at the present time, it is of great moment when considering the ultimate possibilities of producer-gas vehicles as an alternative to petrol or oil-engined vehicles. It should, therefore, be carefully borne in mind, when studying the report, that the conclusions reached apply only to converted vehicles.

In view of the number of proprietary producers already on the market, and the existence of satisfied users, the reasons given for the genesis of the committee's design are not without interest. It is stated in the report that, from their experience in operating the producers on the market, and the difficulties they encountered in obtaining delivery of the producer equipment required for the trials, the committee were satisfied that they should try to develop a simple form of producer equipment designed for rapid production and suitable for the conversion of existing vehicles to run on home-produced fuels. In connection with this statement, it is, perhaps, justifiable to point out that, had the producer-manufacturer been given the same encouragement by the Government in the past as has now been afforded to him by the concessions made in November, the whole of the work of the committee might have been rendered unnecessary. The keynote of the design of the equipment was to be cheapness and simplicity of manufacture by mass-production methods, using plant and methods of manufacture available even in war-time; together with the elimination of the weaknesses revealed by the tests made on other producers. Further, it was regarded as essential that the producer should deal with readily obtainable British fuel, and that its attachment to a vehicle should involve the minimum expenditure of time, skilled labour, and money. It was decided to proceed to the utmost limit of simplification of construction, maintenance and operation. The committee had in mind the possibility of designing a single producer which, with the minimum alteration, would be suitable for all classes of vehicle, but, in the first place, they decided to cater for vehicles up to 6 tons gross weight and of 4-litre engine capacity. The emergency producer designed by the committee is of the cross-draught type, the gas offtake being arranged directly opposite to the tuyere. It consists merely of a thin steel cylindrical shell, about 4½ ft. high by 18 in. diameter, fitted with a fuel-charging door at the top and an ash-discharge door at the base. The gas offtake is protected by a detachable grid and the tuyere is water-cooled, the water for the purpose being stored in a corrugated tank which also forms a radiator, fitted round the upper part of the producer shell. Mild-steel plate is employed throughout, and the tuyere is a mild-steel pressing. Pressings are used, in fact, to the greatest possible extent for ease of production in quantity, being also employed for the top and base of the shell, and for the doors. The latter are interchangeable between themselves and with those on the auxiliary apparatus.

In comparing the producer with others already on the market, attention may be confined to the two of British origin, as it is the manufacturers of these who are most affected by the publication of the emergency design. The British producers are manufactured by Messrs. H.S.G. (Great Britain), Limited, and Messrs. The Brush Electrical Engineering Company, Limited, and both have been previously described in our columns. The emergency producer most closely resembles the former, the only important differences being that, in the H.S.G. model, a small quantity of water is mixed with the entering air at a point near the tuyere outlet, and that, in this producer, arrangements are provided for receiving any clinker formed, without interfering with the operation of the producer. Until recently,

* See ENGINEERING, vol. 148, page 557 (1939).

† Report of the Committee on the Emergency Conversion of Motor Vehicles for Producer Gas. H.M. Stationery Office. Price 9*d.* net.

the Brush producer, which was previously made by the Koela Producer-Gas Plant Company, Limited, differed from the emergency producer in the important respect that the Koela model was of the up-draught type; but, as mentioned on page 70, *ante*, an additional tuyere has now been introduced, by means of which the fire can be localised when required, in a similar manner to that used in cross-diagonal producers. The Koela model also differs from the emergency producer in being provided with a heat exchanger, by means of which vaporised water is mixed with the incoming air; it is fitted, also, with a refractory lining, rendered necessary by the fact that the producer is normally operated on the up-draught principle; and the grate arrangements are more elaborate for the same reason. Apart from the introduction of water, it would appear that the H.S.G. producer, at any rate, differs from the emergency model only in mechanical construction, and it would be of interest, therefore, to know the reasons which led the committee to recommend their own design in preference to an existing type. Some difference of opinion exists regarding the introduction of water or steam with the air blast. As stated in the symposium on "Coal as Fuel for Internal Combustion Engines," read before the Institution of Mechanical Engineers in June of last year, the introduction of water or steam produces hydrogen—a desirable constituent in producer gas on account of its ready ignition properties—as well as carbon monoxide; and, if the correct ratio of fuel gasified by air and by steam can be maintained, it results in a certain increase in the calorific value of the gas. On the other hand, it was stated in the symposium that the problem of controlling the water or steam supply under the extreme variations of load in service was not simple, and might result in heavy thermal losses due to the passage of undecomposed steam through the fire. It is presumably for the latter reason, combined with the desire to reach a maximum degree of simplicity, that a water or steam supply has been omitted in the case of the emergency producer. In adopting this course, however, the committee are at variance with those who have had the widest experience, since not only the manufacturers of the two British producers referred to, but the great majority of Continental manufacturers, incorporate means for introducing either water or steam with the air, thus demonstrating that they regard the advantages of this practice as outweighing the disadvantages. That the difficulties of controlling the water or steam supply are by no means insuperable is sufficiently shown by the numerous published tests of the performance of different producers under varying road conditions. Since it will hardly be disputed that the addition of water or steam increases the thermal efficiency of the plant, it is to be regretted that the report of the committee does not include performance figures for comparison with published results on other producers. They merely state that the design has given such satisfactory results in different types of service that they recommend it for manufacture.

The extensive use of pressings certainly facilitates rapid production in large quantities, but precludes the producer from being manufactured by small firms unless these pressings can be obtained from an outside source. That this is likely to be difficult at the present time is suggested by the fact that the committee specifically state in their report that they would not recommend firms of limited capacity to take up the design. They rightly stress that good workmanship and accuracy in manufacture are of great importance in securing a satisfactory performance of portable producers, but, while this is facilitated in the design recommended, neither of the existing British designs already referred to offers any particular difficulty in this respect. The fact that the emergency producer is not suitable for manufacture by small firms may well militate against its extensive adoption. The widespread employment of producers for road traction, which is now generally recognised as desirable in the national interest, comes at a time when the majority of the larger works are fully occupied on the production of essential war material, and there is already a well-justified outcry that, while the larger works have more business than they can handle, many smaller firms are short of orders. From this point of view, it would appear that, in their desire to secure simplicity, the committee have lost an excellent chance to assist these small firms by incorporating pressings in their design to such an extent. As, however, this restriction does not apply in the case of the established British designs, such firms are not precluded from taking up the manufacture of portable producers, and have thus an opportunity to enter a new market the potentialities of which are difficult to estimate. In the section of the report dealing with fuels, the committee state that the quantities of the two fuels usually considered in connection with producers, anthracite and low-temperature coke, is sufficient to supply approximately 10,000 vehicles, but as producer manufacturers are giving careful attention to modifications in design to enable a wider range of fuels to be employed, this may well turn out to be a conservative estimate.

THE DISTRIBUTION OF THE INDUSTRIAL POPULATION.

A Royal Commission on the Distribution of the Industrial Population* was appointed in July, 1937, under the chairmanship of Sir Montague Barlow, to inquire into the causes which have influenced the present distribution of industry and to consider the disadvantages which have arisen from the concentration of population in large towns. It has recently completed a voluminous and interesting report, which was published by the Stationery Office at the beginning of the present month. This document, which is well worth study by industrialists, virtually consists of three reports; for, while all the members of the Commission agree that national action in dealing with the problem they had to consider is necessary, and that a central authority should be established for that purpose, there is considerable difference of opinion about the constitution and powers of this body. The majority, consisting of the chairman and nine members, propose the formation of a National Industrial Board, "to make research into, advise upon and regulate the location of industry"; but, except within the London and Home Counties area, they do not consider this body should be vested with powers to control the establishment of additional industrial undertakings. Three members of this majority, however, hold that the Board should have powers to control industrial growth throughout the country. A minority of three go even further and think that a Government department, presided over by a Cabinet Minister, should be formed to deal with this problem. This department would divide the country into three types of area: those into which industry would have free entry; those in which, subject to special exemptions only, the further establishment of industry would be prohibited; and those in which a special case for consent to establishment would have to be made out.

As this is a matter which intimately affects engineers and the engineering industry, it may be useful to discuss the conditions which led up to the appointment of the Commission and the reasons it has advanced for holding that changes in the present position are necessary. In doing so, it may be emphasised that, except for the important differences in opinion to which we have called attention, the members of the Commission were all of one mind. In particular, they were unanimous that "the disadvantages in many, if not most, of the great industrial concentrations alike, on the strategical, the social and the economic sides, do constitute serious handicaps and even in some respects dangers to the nation's life and development."

The problem, of course, is not new; and many reformers, including such diverse characters as Queen Elizabeth and Cobbett, have, in years gone by, called attention to its dangers and have suggested methods by which it might be solved. Without going back into such ancient history, it may be mentioned that it has recently been given a new lease of life, partly owing to its own accelerated growth during the last twenty years, and partly owing to its connection with the related problem of the Special Areas. Compulsory location of industry, indeed, has been advocated by some as a sure cure for unemployment and, although this solution was described, in 1936, by Sir Malcolm Stewart, then Commissioner for the Special Areas (England and Wales), as unnecessary, dangerous and likely to cause chaos, at the same time he expressed the opinion that, while the Government should not dictate to industry where it should go, there were good grounds in certain circumstances for laying down where it should not go. He recommended that an embargo should be placed on further factory construction in the London area and also that financial inducements should be offered to attract industries to the Special Areas. These suggestions aroused a great deal of deserved interest. In fact, the appointment of the Royal Commission, which occurred after not more than the usual delays, was the direct result.

The problem that the Commission had to consider falls naturally into three parts: the causes of the present distribution of population; the social, economic and strategical disadvantages of concentration; and the measures that ought to be taken to remedy as far as possible the undesirable features of what is called "conurbanisation." As regards the first part, before the industrial era Great Britain was mainly an agricultural country with a widely distributed population. The first change in this position was a migration from the countryside to the growing local town, since, for obvious reasons, it was natural that a commodity should be produced as near as possible to the place where it was to be sold. Once an industry had been established, however, it created conditions favourable to its own growth and thus regional concentration, due in the first place to natural advantages, fostered local concentration and the growth of large urban areas. This growth, in turn, both encouraged the growth of the original industries and attracted others, so that the district in question tended to grow like a snowball.

This process explains why London, from having been, since quite early days, a centre of handicrafts and cottage industries and above all an important commercial and distributing centre, owing to its topographical advantages, has, more recently, grown to be a large factory centre; and why, within the last twenty years, that growth has acquired an increasing, almost terrifying, pace. The same is true of Liverpool and Hull, which originally were mainly ports. On the other hand, such concentrations as those to be found in the Clyde Valley, the North-East Coast, and East Lancashire, were initially based on mining and manufacture and natural conditions, therefore, played a decisive part in their location. The establishment of the textile industries in Lancashire and the West Riding, however, contrary to general opinion, were probably due more to the fact that "foreigners" were kindly received by the local authorities than to any natural advantages. In all cases, once established, these industries assisted the growth of others, both owing to their own needs and to the demands of those working in them. An attractive force was, therefore, generated which was increased by the existence, as in London, of a large market or, as in Birmingham, of cognate industries.

The results of this townwards movement may be illustrated statistically by saying that while, between 1921 and 1937, the population of Great Britain increased by 7½ per cent., that of London and the Home Counties rose by about 18 per cent., and that of the Midlands by 11 per cent. The rate of increase in the number of insured persons was also nearly twice as high in London and the Home Counties as in the whole country. While this is mainly due to the fact that London houses a much larger proportion of growing industries and a lower proportion of the declining industries than some other places, it is also partly due to the attraction which the area offers to the distributive, general engineering and other trades, owing to the nearness of their markets. The substitution of electricity for coal as

* *Royal Commission on the Distribution of Industrial Population. Report.* London: H.M. Stationery Office. [Price 5*s*. net.].

a motive power and the development of road transport have also operated in the same sense. It seems probable, therefore, that other conditions being equal, this trend will be accelerated. The Commission, however, considers that this trend southward is not inevitable, and could be checked, if it were found desirable. Their solution, as we have already pointed out, is forcibly to prevent the establishment of any more factories in this area.

Discussing the social, economic and strategical disadvantages of this concentration, the Commission points out that, though much has been done to improve the appalling conditions which existed a hundred years ago, when the Industrial Revolution was at its height, statistics show that the country is still healthier than the town. This is due to overcrowding, both of houses and people, and to the reduction of effective sunshine caused by the production of smoke. None of these factors is inevitable, however; and their effects could be mitigated by careful planning and by taking more energetic steps towards the promotion of positive health, including access to fresh air and sunshine and facilities for exercise and recreation. Steps must also be taken, in their opinion, to improve housing conditions; since, while the concentration of industry in large towns was followed by a concentration of population for whom accommodation had to be provided, the construction of the necessary houses was subject to little or no public control, and the creation of slums has been the natural result. The concentration of commerce and industry in the inner areas also often absorbs land originally used for housing purposes. The result is that the workpeople are forced to live farther and farther away from their work, and to expend a great deal of money and time, which might have been more usefully employed, simply in travelling to and fro. Their real wages are reduced, therefore, though they may enjoy improved housing conditions and better health when they are at home.

As regards the economic factors, concentration of industry and commerce gives, as we have already said, the advantages of proximity to markets, a reduction of transport costs, and greater labour availability. On the other hand, it is expensive, mainly owing to high site values, while traffic congestion to some extent offsets any savings on transport. Efficiency and output may also be reduced by the fatigue caused to workpeople who have to travel long distances under uncomfortable conditions. The reasons why such travelling may be necessary have already been given. Though the Report was completed before the war broke out, the Commission is also clearly of the opinion that the concentration of industry is disadvantageous from the strategic point of view, and that no steps that can be taken to mitigate these risks would be quite so effective as dispersal or decentralisation. In this connection, they raise the point whether some of the activities which are now concentrated in London could not equally effectively be carried on elsewhere, and mention a number of Government departments as an example. The outbreak of war has brought a large-scale experiment of this kind into operation, and from it some useful lessons may be learnt. Experience will probably go to show that a great many organisations, including not only Government departments, but private firms, have little real need to be in London, and would function quite as effectively elsewhere.

Finally, the Commission come to the question of how the concentration of the industrial population, which they have already found to be undesirable alike on the strategical, social and economic sides, can be remedied. The problems involved are, they feel, national in character and, therefore, should be investigated by a central authority, whose activities should be distinct from and extend beyond those within the powers of any existing Government department. The duties of this body should include the redevelopment of congested urban areas by the dispersal of both industries and industrial populations, and the encouragement of a reasonable balance of industrial development in each area. The problem of London should receive immediate attention, as should the conflicting claims of garden cities, satellite towns, trading estates, and other appropriate methods of achieving decentralisation. In this connection, such factors as labour supply, markets, transport and power should be considered, not to speak of the avoidance of unnecessary competition, and strategical influences. Local authorities should be encouraged to undertake their development on a regional rather than municipal basis, though private enterprise should not be excluded. The Central Authority should also have powers to control town planning as well as to engage in research and other cognate activities.

Up to this point, and it will be agreed it is a very long way, the members of the Commission are in agreement, though as we have said they are not of one mind as to how these reforms are to be carried out. This is unfortunate, since it deprives the Government of guidance just at that point where a clear lead would have been most useful. It is the more unfortunate since it is extremely unlikely in any event that the legislation necessary to implement their views can be put through or even considered until hostilities cease. In the meantime, more and more factories are being built, and it remains to be seen whether in their location the rules which the Commission has laid down will be followed. They could be followed if desired, since industry is now under some measure of State control, but there are indications that this is not being exercised in the direction the Commission would desire. In conclusion, the urgency of the problem should be stressed. There may be two opinions whether an attempt should be made to solve it; in fact, many industrialists are opposed to such interference. There can be no doubt, however, that the longer it is neglected the more difficult it will be to deal with.

NOTES.

Electricity Supply in Holland.

At the end of last year, the Dutch Minister of Public Works instituted an Electricity Council. This body, of which the president is Professor van Swaay, consists of sixteen members, representing electrical and other industrial interests, agriculture, transport and various social and economic activities. One of the main duties of the Council will be to advise the Government on all matters pertaining to the utilisation of electrical energy, and it is hoped that the combination of the various interests which are represented will result in the recommendations of the Council giving due weight to the many diverse interests which are affected by electrical legislation and regulations. The Council, in addition to advising on matters submitted to it, has authority to make recommendations to the Government of its own initiative, should this appear desirable. In dealing with the many problems relating to the generation, transmission and distribution of electrical energy, with which it will be faced, the Council will have the benefit of the advice of the Bureau of Electricity Supply of the Department of Public Works. This Bureau, which was instituted on January 1, is a more directly technical body than the Council. One of the main problems with which it will have to deal is that of the interconnection of the various electrical generating stations in Holland. This is a matter which has long been the subject of attention and discussion among Dutch electricity-supply authorities. Although the general principles on which this interconnection should be carried out have already been determined, there are many matters still requiring settlement with which the Bureau will have to deal. These concern such questions as voltage and frequency regulation, spare plant, and the protection of overhead lines. Although these questions have been dealt with elsewhere, they have still to be examined from the point of view of the special conditions which obtain in the Netherlands, and adapted to those conditions. Mr. G. J. Th. Bakker, who, since 1914, has been manager of The Hague Municipal Electricity Works, has been appointed Director-General of the newly-formed Bureau. In addition to his long experience in Dutch electricity supply, Mr. Bakker has for many years been an active member of the Conférence Internationale des Grands Réseaux Electrique, of which he is a vice-president. He represented the Dutch Government at the World Power Conference meeting in Washington.

War Damage to Property.

About the middle of December, the Association of British Chambers of Commerce issued a report condemning the Government intentions to make compensation for war damage to property on the highest scale "payable in the light of the country's financial circumstances at the time," and to reject the procedure of obtaining the sums required by some system of insurance. On the other hand, they suggested that the Government should undertake to pay full compensation for damage to fixed property directly after the war and that property owners should compulsorily contribute to a fund for this purpose at the rate of 10*s.* per cent., this contribution being continued until the yield of the premiums, together with the Government contribution, covered payment for compensation in full. This report having been forwarded to the Government, elicited a reply from Sir John Simon last week. In this, he reiterates that it remains the view of the Government, and this is confirmed by the Weir Report, that the extent to which compensation can be given in respect of war damage to property can only be determined after the end of the war, when the total extent of the damage is known, and in the light of the then financial circumstances of the country. "This fundamental consideration makes it impossible for the Government to promise now that full compensation or a specified proportion thereof, shall be payable." Sir John does not see how that position can be modified by a scheme which divides the provision for compensation between the Exchequer and a fund provided by an annual charge on fixed property. Whatever total compensation is ultimately payable, and however it may be provided, it will represent a draft on the financial resources of the country. The amount of such draft which can properly be made must depend on the total call on those resources and on the total demand which the Government will, at the end of the war, be able to make on the taxable capacity of the country, including that of owners of property. He therefore concludes that the Government's policy, as confirmed by the Statement of Policy on the Weir Report, cannot be modified.

Engineering Apprentices and National Service.

The position of engineering apprentices who are nearing the age of compulsory service, but whose desire is to go to sea on completion of their apprenticeships, has been engaging the attention of the Ministry of Shipping, and discussions on the matter have been proceeding for some time between this Ministry and the Ministry of Labour and National Service. An arrangement has now been agreed, it is announced by the Ministry of Shipping, whereby all such apprentices who intend to become engineer officers in the Mercantile Marine shall be registered as "seafaring." The individual apprentices should inform the Ministry of Labour clerk of this intention at the time of registering for national service, and their registration papers will then be marked accordingly and transferred to the appropriate Mercantile Marine Office. As soon as possible after registration, they will be asked by the Registrar-General of Shipping and Seamen to supply details of the extent to which their apprenticeship has been completed; but, until instructed otherwise, they should continue in the same employment. The notice concludes with the request to engineering employers to ensure that the above information is brought to the attention of all apprentices in their works.

Load Building in War Time.

The first of the Informal Meetings of the Institution of Electrical Engineers during the new session was held on Monday, January 29, when Mr. F. W. Purse dealt with "Load Building in War Time." In introducing the speaker, the President said that the output of the Central Electricity Board had fallen seriously during the early part of each evening, largely owing to the loss of shop lighting. Mr. Purse said that, assuming we could once again

go forward, a renewal of publicity and propaganda, with the full support of the Electrical Development Association, was essential. Much could be done to educate the people to make their living happy and comfortable in spite of rationing restrictions and regulations. Demonstrations on wartime cooking and effective indoor lighting might well be given and attention should be paid to much of the apparatus which had been hurriedly installed in canteens and placed in charge of unskilled volunteers. Agriculture, as an essential to the life of the community, was rapidly growing in importance and there was a great opening here to substitute electrical for man power and to use this form of energy for lighting and heating rather than imported oil. Imported oil could also be saved by the greater use of trolley 'buses and other electrical vehicles. The transfer of population from one district to another had led to a surplus of apparatus in one place and a shortage in another. Instead of pressing manufacturers for new equipment, resources might be pooled. The savings demanded by the Government could best be obtained by a greater and not a lesser use of electricity.

Pay in the Merchant Service.

Increases in pay for both officers and men serving in British merchant ships have been announced by the National Maritime Board, and are to take effect on and from March 1. These are the result of discussions which have been proceeding at meetings of the panels representing the navigating and engineer officers, the sailors and firemen, and the catering personnel. The announcement states that the rates of pay of navigating and engineer officers, as laid down in the standard scale of the National Maritime Board, are to be increased by 2*l.* per month and 10*s.* per week. Further discussions are continuing regarding requests for the regulation of officers' working hours, and a statement on this point is to be expected shortly. Claims submitted a month ago by the National Union of Seamen have been considered by the Shipping Federation and it is agreed that the National Maritime Board scales for ratings shall be increased by 1*l.* per month and 5*s.* per week; the increase for boys is to be half this rate. The war-risk payment of 5*l.* per month and 1*l.* 3*s.* 4*d.* per week, with half these rates for boys, which is paid to all seafarers, is to continue as at present. It is agreed in principle that ratings should have periodical leave, with pay, in the United Kingdom. Government sanction is also to be sought for the issue to officers and seamen of two free rail vouchers per annum, as in the case of the Royal Navy.

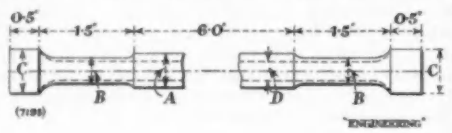
TEST-PIECE FOR INVESTIGATING THE YIELD POINT IN IRON AND STEEL.

By A. M. Baxter and C. F. Elam (Mrs. G. H. Tipper).

Considerable attention has been paid to the part played by shape of test-piece and stress concentration at the shoulders on the value of the upper yield point in iron and steel. The "streamlined"* test-piece was designed to reduce these stress concentrations to a minimum, and it has been claimed that higher values were always obtained for the upper yield point when such precautions were taken, values for the lower yield point remaining constant. Even with very long test-pieces and a gradual taper, there is still some localisation of stress due to change in cross sectional area and uncertainty in calculating the stress at which failure begins. Further, elongation measurements are unreliable, particularly when obtained only from an automatic load-extension record. In order to obtain a test-piece free from the above disadvantages, the following device was adopted: a test-piece was prepared, 10 in. long, having the shape and dimensions shown in the annexed figure.

On loading such a test-piece, the two small-diameter ends will extend a certain amount before the stress is sufficient to cause yielding in the centre portion. If, after the ends have yielded, the test-piece is turned down until the diameter is the same throughout, a test length is obtained in which the ends being hardened by cold work, perform the same function as enlarged ends in an ordinary test piece, without the disadvantage of change of shape. Any stress concentration that exists, must be between strained and unstrained metal only

A mild steel containing 0·16 per cent. carbon was used for the preliminary tests described here. After turning, the test-pieces were normalised in a vacuum furnace. They were strained in a Quinney autographic testing machine. The load fell as



Specimen.	A. In.	B. In.	C. In.	D. In.
1	0·5	0·35	0·7	0·334
2	0·5	0·35	0·7	0·334
3	0·5	0·4	0·7	0·382
4	0·5	0·4	0·7	0·364

soon as one end began to yield and the extension was carried on until both ends had yielded (as indicated by measuring with dividers and micrometer) and the load began to rise again. Both ends were found to have extended to about the same amount, although this is immaterial, provided the extension is sufficient in each. The test-pieces were boiled for 15 minutes, as this treatment has been found to raise the yield point in the strained material, and then turned down parallel, a small cut being taken also off the smaller-diameter ends. One difficulty could not be obviated in this method: the surface of demarcation between strained and unstrained metal was probably irregular, owing to the formation of Lüders lines in this region. When pulled, these test-pieces gave a normal load-extension diagram, showing a drop on first yielding and a flat lower yield before the load rose again. No extension could be measured in the strained ends until the centre portion had yielded and the load began to rise.

Four specimens were tested. Their dimensions are given below the figure and the yield points

Table of Yield Points.

Specimen No.	Stress, Tons per Sq. In. on Small-Diameter Ends.		Stress, Tons per Sq. In. After Turning to Uniform Diameter.	
	Upper Yield Point.	Lower* Yield Point.	Upper Yield Point.	Lower Yield Point.
1	24·75	22·4	27·4	24·2
2	25·15	22·4	26·95	24·2
3	32·0	28·9	28·8	24·15
4	31·7	29·6	27·5	24·0
Mean	27·12		27·16	

* The lowest point on record. Value uncertain.

obtained are given in the above table. The value of the upper yield point does not seem to depend so much on the shape of the test-piece as might have been expected, but the results in the turned-down specimens are very uniform both in values of upper and lower yield points. Greater variation is not surprising in irregular-shaped test pieces. It is interesting to note that the mean is the same in both cases. The difference between upper and lower yield points of these turned-down specimens may be regarded as a measure of the stress concentration between strained and unstrained metal.

These experiments, which were carried out at the Engineering Laboratory, Cambridge University, are only of a preliminary nature, and it is not possible for the present writers to carry out further tests with other steels and different heat-treatments, in order to investigate the method fully.

* J. G. Docherty and F. W. Thorne, Engineering, vol. 132, page 295 (1931); H. Quinney. *The Engineer*, vol. 157, page 332 (1934), and vol. 161, page 669 (1936).

METALS AS ENGINEERING MATERIALS—I.

The first of a series of three Cantor lectures, dealing with "Metals as Engineering Materials," was delivered by Dr. C. H. Desch, F.R.S., at the Royal Society of Arts, Adelphi, London, W.C.2, on the afternoon of January 29. In his opening remarks, Dr. Desch stated that the dependence of engineering on the use of metals, so characteristic of modern civilisation, was a fact of quite recent origin, dating from the industrial revolution of the Eighteenth Century. That revolution, as defined by economic historians, had been preceded by a mechanical revolution. It was the introduction of steam and of certain inventions, particularly that of Arkwright, which had made possible the transformation of industry from a small to a large-scale activity. The mechanical revolution itself had only been made possible by improvements in the manufacture of iron, which had made large masses of the metal available and so permitted the construction of quickly-moving machines. This tardy utilisation of metals in industry, when closely examined, was somewhat remarkable. The knowledge of metals came late in the history of mankind, as measured by years, but it was earlier than the formation of civilisations complete enough and extensive enough to have left a mark on history. When the marvellous achievements of both Mesopotamia and Egypt in civil engineering were considered, it was remarkable how little they were dependent on the use of metals, except in the form of tools. The casting of beams was no doubt impracticable on account of the lack of means for melting a sufficient quantity of bronze at one time, while cast iron was a comparatively late invention. The size of forged masses, on the other hand, was limited by the necessity of using only hand hammers. Where iron forges were in use, fairly heavy masses of iron were sometimes required to serve as anvils. The technique of manufacturing iron directly from the ore in a bloomery remained remarkably constant throughout many centuries, and varied little in different lands.

It appeared that the use of metal beams or bars in the construction of buildings, even in mediæval times, was very limited. Cramps for holding stone together were not uncommon, but metal never formed an important structural member. Besides civil engineering, however, the ancients practised another art, namely, that of military engineering, but, for the most part, wood and cords entered into the construction of the great siege engines employed, which survived until after the introduction of gunpowder, and metals were confined to iron shoes for battering rams, ratchets for retaining the cords when taut, and similar uses. In the Sixteenth Century, two famous works appeared, the *De Re Metallica* of Agricola (1556), and *Le Diverse et Artificiose Machine del Capitan Agostino Ramelli* (1588). Both these writers described machines intended to move heavy weights or to deal with large quantities of water or earth. Here again wood was the principal material, with iron for pivots and other small component parts. How elaborate such machines could be was shown by the cranes described in Ramelli's work and there was no doubt that they were a success in practice. The contemporaries of Agricola and Ramelli, however, had one constructional material at their disposal which had not been available to the ancient or early mediæval engineers. This was cast iron, the first blast-furnaces having made their appearance in Western Europe during the Fourteenth Century. It was not until the latter half of the Fifteenth Century that they were erected in England, and most of the metal produced was used to make wrought iron by the indirect process, although some was made into castings in sand moulds. About a century later, in 1543, the first cannon were cast in England, and the later art of iron-founding was linked with the making of ordnance. By the early part of the Eighteenth Century cast iron had become familiar, as Sorocold used it for the four-throw crankshafts, pump barrels, and pipes in his reconstruction of the London Bridge waterworks. Increasing boldness was shown in the handling of metal masses and it was, in fact,

the improvement of the iron industry in the Eighteenth Century which made possible the machine age.

Cast iron, wrought-iron forgings made by welding together numbers of bars, steel of irregular texture made from puddled material, and crucible steel for small special parts, held the field until the middle of the Nineteenth Century, when the whole situation was changed by the inventions of Bessemer and of Siemens. Further, the restriction of both processes to iron very low in phosphorus was removed when Thomas and Gilchrist invented the basic process in 1878. One of the first and most successful applications of Bessemer steel was for rails, and the new material was soon adopted for boilers and for railway rolling-stock tyres and axles. Naturally, as the Siemens process grew in importance, its products were found to serve the same purposes as Bessemer steel. The control of the carbon and manganese came to be understood and the early prejudices disappeared before the successful advance of the industry.

During the last third of the Nineteenth Century attention was directed to a factor which had not before been recognised as important, namely, the effects of repeated stress. In a slowly-moving machine, the stresses might be considered as essentially static, but, in a quickly-moving machine, on the other hand, parts were highly stressed, the factor of safety was reduced and concentrations of stress assumed a new importance. Hence it became necessary to know the resistance of the parts to repeated stress, *i.e.*, to fatigue, and it was this consideration which had been largely responsible for the development and use of alloy steels as constructional materials in engineering. Another recent development, and that a truly revolutionary one, was the introduction of light alloys, the use of which, although characteristic of the aircraft and motor-car industries, was by no means confined to them. Apart from their extensive use in the chemical industry and for domestic purposes, there were many examples of machines and structures in which a saving in weight was an advantage. A rather striking instance was the reconstruction of the Smithfield Street Bridge at Pittsburgh, which, having been condemned as being insufficiently strong for the increasing traffic, was lightened, as regards its dead weight, by replacing the wrought-iron road girders and floor by aluminium alloy, thus allowing it to be used by 20-ton lorries. Prior to the reconstruction, only 13-ton vehicles had been allowed to pass over the bridge.

Viewing past achievements, it was evident that in each instance a metallurgical revolution had preceded a mechanical revolution and new and more efficient machines had been developed as materials for their construction had become available. In return, the stimulus given by engineering development to research in metallurgy had been very great. While, however, some of the earlier inventions had been the result of a chance discovery or a happy guess, such an event was very unlikely to occur at the present time. The progress of invention followed closely, and was dependent on, that of systematic research.

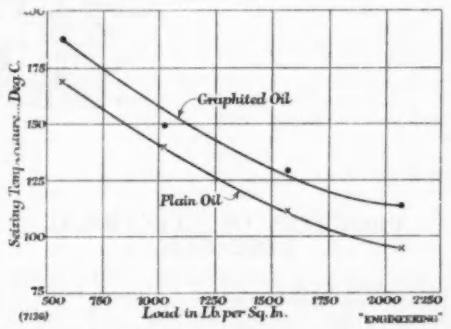
THE CONSERVATION OF LUBRICATING OIL.

By A. H. STUART, Ph.D., B.Sc.

THE pooling of the nation's oil resources to meet war-time conditions is a measure which will not be fully effective unless the users of lubricating oil co-operate with that understanding which will ensure that all the oil distributed is utilised to the best advantage. This is a subject which naturally falls into two aspects, namely, the economical use of new oil and the reclamation of used oil; the latter will now assume greater importance than ever. The writer's interest in lubrication problems was awakened some thirty years ago by watching a mechanic put a considerable quantity of oil on the bed of a lathe, and noticing that the greater part of the oil was swept on to the floor by the first traverse of the lathe saddle. This inspired a test in which the coefficient of friction between the lathe bed and saddle was measured under different conditions of lubrication. Actually, the friction was found to be least when the bed was merely wiped over with an oily rag, surplus oil involving greater effort. In this connection it will be recalled that, in the Michell thrust block, the film of oil is very thin at the seat of the load. It is only in recent years that workers on lubrication problems have realised the importance of the reactions of the metal and oil surfaces in a bearing as opposed to the properties of the oil itself.

In recent discussions on lubrication it has been generally accepted that the time has come when the lubricating properties of an oil cannot be further improved by extended "refining," that is, taking something out of the oil, but only by putting something into it. A casual glance at recently published literature on lubrication is sufficient to show how much importance is now attached to "additives." It may well be that, in the pooling of oil resources, a user may be supplied with an oil which does not contain the additive to which he has been accustomed; while such an oil may be quite satisfactory as regards viscosity and the absence of gumming and sludging tendencies, its behaviour under given working conditions, such as bearing load, speed and temperature, may be the reverse. This point will need watching, especially as war demands will entail in many cases continuous running or increased loading.

Again, it is probable that the stress of war will cause many oil users to turn to reclamation processes which hitherto have not been considered worth pursuing. To the majority, the reclamation of oil means only filtration; and those who have watched the development of oil filters over the past two or



three decades will be aware of the evolution of the oil filter, from a septum which acted as a mere strainer to something of a very different character, involving physical and chemical processes which, strictly speaking, are not filtration at all, according to the dictionary definition of that word.

The writer is probably not alone in having had his attention drawn to the beautiful golden colour of an oil by those endeavouring to sell it. So long as this colour is regarded as a selling asset, refiners will strive to produce it. It is necessary to treat edible oils, such as olive oil, in this way, and it is generally achieved by passing them through some adsorptive material, such as fullers' earth or activated charcoal. These materials, owing to their surface energy, have the power of adsorbing those substances which have a physical attraction to their surface. When a lubricating oil is "refined" by means of a filter of the fullers'-earth type, it is possible for the adsorptive property of the filtering septum to attract and retain just that part of the oil which might have been adsorbed by the metal surface of the bearing. Under normal loads and temperature, this loss might not be very evident; but, should an abnormal load be imposed or an unexpected temperature be reached, the oil film would be more easily ruptured, since it would, so to speak, lose its hold on the metal surface, owing to the loss of its adsorptive component.

Most lubricants consist mainly of a mineral oil, because this is so stable under the combined conditions of high temperature and exposure to oxygen. The lubricating properties are greatly improved, however, by the addition of small quantities of vegetable oils. Such oils, while reducing the coefficient of friction and making for cooler running, are less stable chemically and under certain conditions are liable to form sludge. In many cases, the sludging tendency of an oil is enhanced by the presence of a catalyst, of which copper and the copper alloys are among the best known. To counteract this objectionable tendency, since copper and copper alloys often form a necessary part of the mechanism to be lubricated, inhibitors are sometimes incorporated in a lubricating oil. Among those inhibitors which have found favour, tin oleate and chromium oleate may be mentioned; while, more recently, certain organic compounds such as phthalamide have been found to be effective. Most of the additives which have been employed to bring lubricating oils to their present degree of excellence, have been necessarily incorporated by the oil factors under expert control, and it is hardly to be expected that this will be done by the average user of oil, under war conditions. There is one additive, however, which has been extensively used during recent years, and this is colloidal graphite. It has been the custom for the oil factors to incorporate it, but there is no reason why it should not be added to any suitable oil by anyone capable of following simple instructions, as its use as an additive to lubricants is standardised in both quality and quantity.

In the well-known "dag" colloidal graphite there is a dispersion of particles of pure graphite in oil, the particle size being of the order of 3 millionths of an inch. These minute particles of graphite readily adhere to many bearing metals, including the cylinder walls of engines, and produce a surface which exhibits valuable properties; not only does it offer less friction when normally lubricated with oil (resulting, in the case of an engine, in an increased output of power),* but, should the oil film be ruptured through excessive load or temperature, the graphoidal surface alone will afford a high measure of lubrication and ensure a rapid spread of oil when the supply is restored. In this way the presence of colloidal graphite in a lubricant is a valuable means of warding off seizure when adverse conditions are imposed. The beneficial use of colloidal graphite as an additive to oil employed in running-in new engines or other machines is also generally recognised. Figures obtained on the test bench have shown that this benefit is substantial.†

The question has been raised, whether this benefit is confined to the running-in period, and the experience of some users has tended to show that no observable advantage is shown by a graphited oil under normal working conditions; but war brings conditions which are far from normal, both within and without the workshop, and it is under abnormal loads and temperatures that a graphited oil is undeniably superior to any form of plain oil.

An exhaustive series of experiments, carried out at the National Physical Laboratory, has demonstrated that, under high loading, the coefficient of friction in a bearing is less with a graphited oil than with the same oil used plain. The running temperature of such a bearing is measurably lower. A test of considerable interest was made, in which a bearing was artificially heated and the temperature at which it seized was recorded. A set of these results is shown in the diagram herewith, and indicates a higher seizing temperature at all loads when a graphited oil was used. In another test, white-metal bushes, 2 in. in diameter, were run in contact with nickel-chrome steel journals at a speed of 500 r.p.m., and under a load of 230 lb. per square inch. The lubricant was reduced until the bearing seized. It was found that it required 0·017 fluid oz. per minute to prevent seizure in the case of a plain oil, but 0·005 fluid oz. was sufficient when the oil carried colloidal graphite. This result was independent of whether the lubrication was drip-fed or otherwise. In addition to its anti-friction properties, the graphoidal surface developed when a graphited lubricant is employed has anti-corrosive properties which have proved valuable where the bearing surface is exposed to adverse conditions of temperature or moisture, such as may exist on the cylinder walls of internal-combustion engines.‡ Finally, there are many cases, where lubrication is required, in which any form of oil is undesirable

* See ENGINEERING, vol. 145, page 142 (1938).

† *Ibid.*, vol. 145, page 71 (1938).

‡ *Ibid.*, vol. 145, page 260 (1938); *The Automobile Engineer*, vol. 28, page 318 (1938).

or even impossible. Here a graphite dispersion in other media, such as water or glycerine, has given good results.

It is interesting to consider what happens when a graphite oil is filtered. Few filters are capable of retaining by simple filtration particles so small as 3 millionths of an inch, but, just as some filters will retain by adsorption components of a lubricant which are not solid at all, so some of these filtering septa will retain a portion of the graphite by adsorption, the physical principles operating being the same as those which cause the attraction between the graphite particles and the metal surface of a bearing. In such cases, of course, it is necessary to replenish the graphite in a reclaimed oil. If an oil is cleansed by means of a centrifuge, with or without steam treatment, very little of the graphite is removed. Experiments by the writer* and others have shown that the objectionable tendency to sludge formation in an oil is definitely reduced by the presence of colloidal graphite.

THE CLIMAX WODACK ELECTRIC DRILL.

THE electric drill shown in the accompanying illustrations, Figs. 1 to 3, is of particular interest in that it is designed for two distinct types of operation, *i.e.*, it can be used with the ordinary rotating motion for drilling, grinding, buffing, etc, or with a reciprocating motion for boring holes in concrete, brick or masonry, or for chipping, etc., the conversion from one purpose to the other occupying a matter of half a minute only. The tool, known as the Climax Wodack Electric Drill, has been developed recently by Messrs. The Climax Rock Drill and Engineering Works, Limited, Carn Brea, Redruth. The external view, Fig. 1, shows it arranged for the reciprocating motion, the sectional view of Fig. 2 also showing the hammer member. In Fig. 3, the drill is shown as arranged for the rotating motion and, since the reciprocating motion is derived from the rotating spindle, reference should be made to this illustration first. The motor is of the universal type, operating either on direct current or on single-phase alternating current of 50 cycles or less. The armature spindle is carried at both ends in ball bearings and a fan is mounted on its output end, thus ensuring efficient cooling not only in the motor chamber itself but in the switch chamber contained in the hollow pistol-grip handle. The switch is operated by the index finger of the holding hand and is readily accessible by removal of a cover. The tool spindle is carried in adjustable Timken tapered-roller bearings for radial thrust and in double ball bearings for end thrust, and is fitted with a No. 32B Jacobs chuck. The capacity, when drilling in metal or wood, is a hole $\frac{3}{4}$ in. in diameter.

Referring to Figs. 1 and 2, the nose of the drill body will be recognised at the right hand, the hammer housing being slipped over this nose and securely gripped by a bolt through its split end. The bolt is recessed into the nose to prevent end movement. The housing itself is a single part and there are no bolted or screwed joints to work loose by vibration. The right-hand part is cut away to provide access to the chuck, etc. The openings are seen in Fig. 2, but are not visible in Fig. 1, where they are covered by a slotted shield of light metal. Movement is transmitted to the percussion spindle by a cylindrical yoke piece rotated by the chuck, the thrust set up on this yoke being taken by grease-packed precision ball bearings. The yoke is formed with an inner wall cut obliquely, and in contact with the cam-shaped face thus provided are a pair of lugs on a nut screwed on the percussion spindle. Helical springs ensure contact between the two parts at all phases of the reciprocating movement, which, it will be recognised, follows the rotation of the yoke. The drill or chipping hammer is carried in a socket and a helical spring prevents the housing cap from working loose. When used as a drill, this attachment will drill a hole to a depth of 3 in. in dense concrete in one minute. The maximum size of hole that can be drilled is $\frac{7}{8}$ in. diameter. It is stated that the holes thus drilled are clean and true to diameter, so that they are particularly suitable for anchor bolts of the expanding type. In softer material, such as brick walls, it is claimed that the time required is only one-quarter of that needed for hand percussion drilling.

SWISS SAMPLE FAIR, BASLE.—The 24th annual Swiss Sample Fair will be held at Basle from March 30 to April 9.

* See ENGINEERING, vol. 145, page 215 (1938).

CONVERTIBLE ROTARY AND RECIPROCATING DRILL.

THE CLIMAX ROCK DRILL AND ENGINEERING WORKS, LIMITED, REDRUTH.

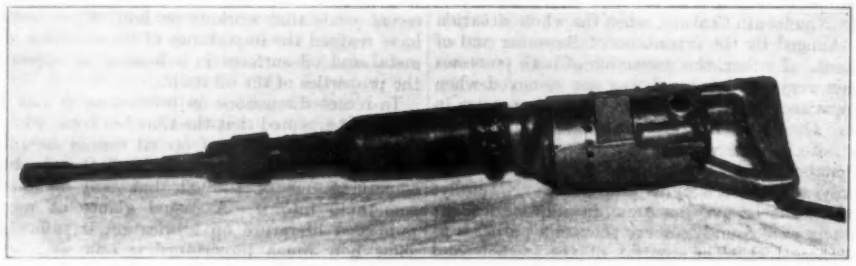
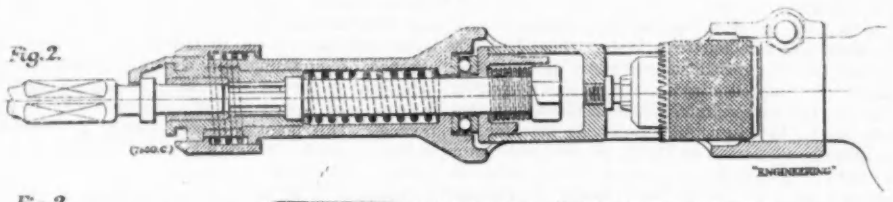
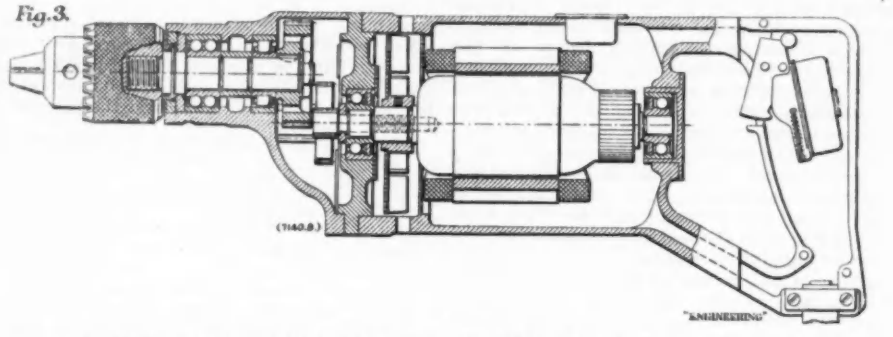


FIG. 1.





PROGRESS OF ELECTRICAL RESEARCH.

THE nineteenth Annual Report of the British Electrical and Allied Industries Association, which has been published recently, covers the twelve months ended September 30, 1939, and, therefore, deals almost entirely with pre-war conditions. In the chairman's foreword, however, the point is raised whether, as all must now be subjugated to one idea, it is in the best interests of the country that the Association should not only be kept in being, but its activities, if possible, intensified. Fortunately, the Government has provided the only correct answer to this question by deciding that all important members of the staff are in a reserved occupation, and by deprecating any reduction in its activities. It is laid down, in fact, that these should be "infused with even greater vigour than before." It is to be hoped, therefore, that members will ensure that the Association do not lack the funds necessary for carrying on what is most important work.

Continued and increasing support is being given by members in the Dominions, and close contact is also being maintained with such bodies as the British Standards Institution, National Physical Laboratory, and various scientific and educational institutions. During the year under review, the Advisory Council of the Department of Scientific and Industrial Research reported favourably on the work undertaken in the laboratory and, owing to the increase in the amount of work, plans have been prepared for the erection of a new three-storey building. For the present only the middle portion of this will be constructed, adding about 4,000 sq. ft. of useful floor space. This work has now been put in hand, an indication in itself of the utility of the work the Association is doing.

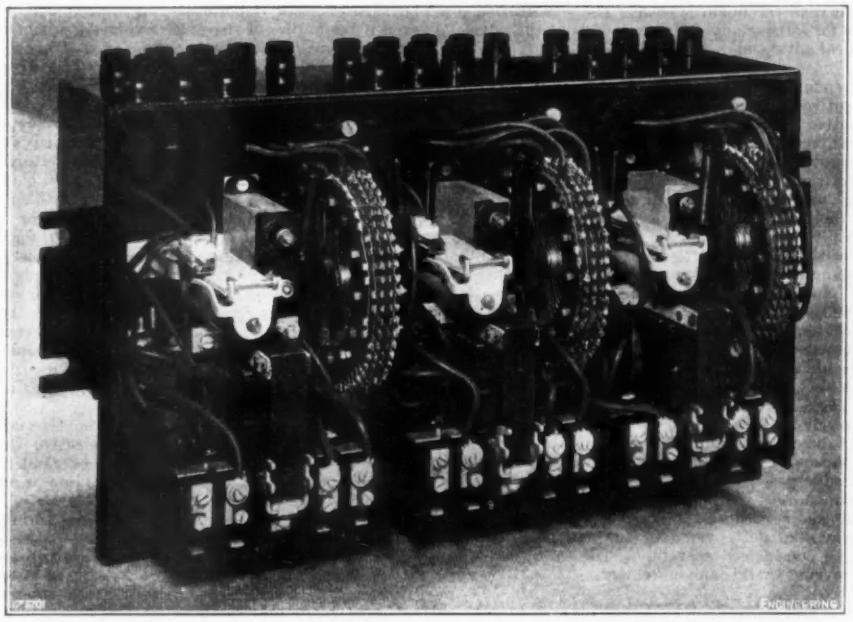
Among new developments of the Association's work that are noted in the Report, mention may be made of the study of problems arising from the heating of buildings by electricity. It appeared that space heating by electrical means was being developed without adequate information, and various difficulties were met with in securing the desired results on a given installation. Particularly hard cases had arisen in dealing with the heating of school buildings, due to the peculiar nature of the load and other circumstances. The best methods of heating under the different conditions met with have not been adequately considered, either in relation to building design or with a view to utilising the peculiar properties of electrical apparatus to the best advantage, and authoritative information is required by the industry and for the guidance of architects. A committee has been set up, therefore, to consider such questions as the thermal properties of buildings, ventilation and air conditioning, comparative efficiencies of methods of heating, economic regulation, and type of load, in relation to the economics of electricity supply, and the comparative costs of different methods of heating.

Encouraged by the Electricity Commissioners and others, there has been some expansion and acceleration of work on rural electrification. One section of this deals with the design and economic aspects of distribution systems, and draft recommendations for a standard specification for 11-kV transformers for use in rural areas have been prepared. Investigations are also in progress on materials for overhead lines. The other section deals with the study of the applications of electricity to agriculture and horticulture. In this, research and experiment are proceeding along three lines. In the first place, certain existing applications of electricity are being studied experimentally with a view to putting them on the best practicable basis. For instance, electrically-heated grain-sprouting cabinets and poultry-rearing appliances are being tested, while methods of soil heating and sterilisation are being investigated. The second line of investigation is concerned with the improvement of the load factor of electrical apparatus, while the third is directed to the exploration of new applications of electricity and their possibilities. Under this heading, work has been done on the heating of young pigs and on the use of electrical methods of killing eel worms in narcissus bulbs. Research on the light irradiation of growing plants has had to be abandoned owing to the difficulty of screening illuminated glass houses at night.

As an important part of the work on surge phenomena, carried out for the Central Electricity Board, the staff has sought to develop new and better apparatus and methods of dealing with disturbances, particularly with lightning. As a result of the intensive work done, certain possibilities emerged and were successfully pursued, resulting in the development of a new type of surge filter. This performs the functions of the present lighting arresters and surge absorbers, showing material advantages and admitting of produc-

CONTROL GEAR FOR SOOT BLOWERS.

MESSRS. BRITISH THOMSON-HOUSTON COMPANY, LIMITED, RUGBY.



tion at low costs. A semi-commercial model was under construction at the end of the year. The fundamental work being done on the subject of dielectrics is increasing in interest and imp rtance but is, as yet, mainly of a type appealing to the expert. The same is true of the work being carried out on magnetic materials, though, in both cases, close contact is being maintained with industry.

ELECTRICALLY-OPERATED SOOT-BLOWER EQUIPMENT.

THE electrically-operated soot-blower equipments, which are now being constructed by the British Thomson-Houston Company, Limited, Rugby, as the result of experience gained during the past four years, differ from their predecessors in being less expensive. Another advantage is that the new control arrangements result in a more compact unit than in the earlier equipment; in fact, it has been possible to halve the floor space occupied. Very little alteration to the actual blower heads is required, it being only necessary to fit a small limit switch. The equipment is also adaptable to any make of head.

The control equipment comprises a master panel for all the heads and a control unit for each head. The appearance of the latter will be gathered from the accompanying illustration, which shows the standard arrangement of three control units. In practice, these are mounted in a dust-tight enclosing cover, which has been removed for the purposes of photography. The compactness of the arrangement will be realised when it is mentioned that the dimensions are only about 16 in. by 9 in. by 8 in. overall, while the master panel occupies about twice this space. These triple units are arranged for mounting in racks either in a special cubicle or in the cubicle of some other boiler-house equipment, such as the control panel. The push buttons shown enable automatic operation of the blower heads to be effected in sequence, or, alternatively, allow each head to be blown individually. Provision is made for reading the control of any individual head in operation, when desired, either in sequence or otherwise. The number of blows given by each end can also be altered by changing the connections on the control unit.

THE COMMERCE OF FINLAND.—In a normal year, 80 per cent. of Finland's exports comprise timber, pulp and paper. Latterly, however, the mineral and agricultural resources of the country have been developed. In 1938, Great Britain took 43·9 per cent. of the exports from Finland but supplied only 21·6 per cent. of her imports.

THE LATE MR. S. F. EDGE.

ALTHOUGH the name of Mr. S. F. Edge, whose death, on Monday last, we regret to record, will probably best be remembered in connection with motor racing, he was a capable engineer whose ideas at one time had a considerable influence on design. Selwyn Francis Edge was born at Concord, New South Wales, in 1868, but he came to England at a very early age. Like many of the early motoring pioneers, his first interest in road transport was aroused through the development of cycling, and after winning the Westerham Hill climb on a safety bicycle, he obtained a position on the staff of the Rudge Company. Soon after, he joined the Dunlop Tyre Company, of which he was made general manager before leaving the firm in 1896. In that year he purchased a Panhard-Levassor racing car, and thus commenced an association with road racing which brought his name into great prominence for many years. Shortly after leaving Messrs. Dunlop, he persuaded the late Montague Napier to take up the manufacture of motor vehicles. While he himself played an important part in the development of the famous Napier firm, he also introduced De Dion Bouton cars into this country, and founded the Gladiator business. The first Napier car, a single-cylinder, 9-h.p. model, was built in 1900, and only four years later the firm produced a six-cylinder car of 18 h.p. Edge, who was then associated with the Napier business, being a strong advocate of the multi-cylinder engine. His faith in the same type of engine was again strikingly shown many years later, when he introduced a small-capacity six-cylinder Acedes car at a time when small cars were invariably four-cylinder models. Other developments in design which owed much to his advocacy were the substitution of shaft for chain drive and the employment of battery in place of tube ignition.

It is unquestionable that the high reputation enjoyed by Napier cars before the firm gave up motor manufacture in favour of other products was due in no small part to the success obtained by Edge on this marque in motor racing. Thus, among other successes, he drove a Napier car, in 1907, round Brooklands track for 24 hours, establishing the remarkable record at the time of 1,581 miles 1,310 yards, representing an average speed of over 65 m.p.h. This record stood for many years in this country, being finally beaten, after 17 years, by an A.C. car, a model with which Edge was closely associated. Among his numerous other successes in motor racing, special mention should perhaps be made of the Gordon-Bennett Cup race in 1912, since Edge was the only British winner of this classic race. Apart from road racing, he was, at one time, keenly interested in motor-boat racing, sharing the two tastes in common with the late Henry Seagrave and with Malcolm Campbell, and, here again, his successes were of great value in demonstrating the reliability of Napier engines. Edge won the International Harmsworth Motor Boat Trophy and the Championship of the Sea at Monaco, for which he was made Chevalier of the Principality.

He sold out his interests in the Napier firm in 1912, and for some years devoted his attention to farming. While particularly interested in pig-breeding, he was a pioneer in the use of light mechanical tractors in farming. Actually, his pedigree-pig breeding business was the largest in the country. He returned to motor manufacturing in 1921, becoming governing director of A.C. (Acedes) Cars, Limited. In 1917, he was appointed Controller of the Agricultural Machinery Department of the Ministry of Munitions.

THE LATE MR. A. S. BAILEY, O.B.E.

WE note with regret the death of Mr. Arthur Stowey Bailey, which occurred on February 11, at his home at Moor Park, Northwood, Middlesex. Mr. Bailey, who retired seven years ago from the managing directorship of the Metropolitan-Cammell Carriage and Wagon Company, Limited, and previously had a distinguished career as an engineer official of Indian railways, was born in 1868. He was educated at private schools and afterwards became a pupil, first in the Lillie Bridge Works of the Metropolitan District Railway, and then at the Nine Elms Depot of the London and South Western Railway. While still a young man, he was appointed manager of the Jamalpur Works of the East Indian Railway. Some years later he was made deputy locomotive superintendent at Jamalpur, but relinquished this post on appointment to the position of chief mechanical engineer of the Bengal-Nagpur Railway. While serving in this capacity he established a reputation as an organiser by his labours in the laying out and management of the new locomotive, carriage and wagon works at Khargpur, and in the planning of the town which grew up in the vicinity of the works. On returning to this country in 1911, he was appointed manager in the London office of Cammell Laird and Company, Limited, and during the last war acted as general manager of the National Ordnance Factory, at Nottingham.

After the conclusion of hostilities, Mr. Bailey was made managing director of the rolling stock works, at Nottingham, of Messrs. Cammell Laird and Company, and continued in this capacity until December, 1927, when this section of the firm was merged with the carriage and wagon-building interests of Messrs. Vickers Limited, to form the Metropolitan-Cammell Carriage, Wagon and Finance Company, Limited. Mr. Bailey was appointed managing director of the new company, and continued in this capacity until his retirement in 1933. He was elected an associate member of the Institution of Civil Engineers in 1894, and was transferred to the class of member in 1904.

THE LATE MR. FREKE FIELD.

AN interesting link with the beginnings of marine engineering has been broken by the death, on February 4, of Mr. Freke Hamilton Field, who was formerly associated with the firm of Maudslay, Sons and Field, of Lambeth. Mr. Field, who was born at Twickenham on March 13, 1860, was the third of the twelve children of Joshua Field, and a grandson of Joshua Field, F.R.S., one of the founders of the Institution of Civil Engineers, and the partner of Henry Maudslay. Freke Field was only 3 years old when the elder Joshua Field died in 1863, but he retained distinct recollections of his grandfather; and, of course, he grew up in close association with the late Charles Sells, whose personal connection with the firm extended from 1837 to its dissolution in 1900. Thus, he was able to discourse with unusual certainty about engineering events and personalities which, to engineers of the present century, were legendary.

Mr. Field himself did not long retain his connection with the firm or with engineering, save in one particular. On leaving Eton, he entered the Lambeth Works, where he remained for some years after attaining his majority, before deciding to forsake engineering in order to develop more fully his natural aptitude for painting. In this pursuit, he lived for many years on the Continent, returning eventually to Greenwich, where he had resided for the last 25 years. Before he went abroad, however, a group of apprentices in the Maudslay works had decided to start an engineering society, of which Mr. Field became the first president. Fifty years later, he was persuaded to emerge from his retirement in Greenwich to attend the anniversary luncheon of the society, which had become, meanwhile, the Junior Institution of Engineers. In the following year, he unveiled a tablet, erected by the institution in Lambeth North station on the Bakerloo Railway, to mark the site of the Maudslay works. This was his last appearance at any meeting of the institution with which he had been so long associated.

LABOUR NOTES.

THE Ministry of Labour and National Service estimates that at January 15 there were 1,518,896 unemployed persons on the registers of Employment Exchanges in Great Britain, as compared with 1,361,525 at December 11, 1939, and 2,039,026 at January 16, 1939. Of the total number, 1,219,503 were wholly unemployed, 249,723 temporarily stopped, and 49,670 normally in casual employment. Of the wholly unemployed, 805,026 were men, 38,427 boys, 319,691 women, and 56,359 girls, and of the temporarily stopped 184,960 were men, 3,086 boys, 58,191 women, and 3,486 girls.

It is pointed out that the count of unemployed persons on the registers of employment exchanges in Great Britain on January 15 was taken on a day when, owing to the severe weather, work in the open was in very many cases impossible, and large groups of workpeople were temporarily idle on this account. The industry hardest hit was building, but the effect was felt to a greater or less degree in many other industries. The January figures normally show a large increase over the December figures owing to the cessation of Christmas activities. In the present year this tendency was less marked than usual. There was, as always immediately after the end of a school term, a temporary increase in the juveniles on the register owing to the accession of "school-leavers." There was a decrease in unemployment as compared with December in a number of industries, notably in coalmining.

Between December 11, 1939, and January 15, 1940, the number of unemployed persons on the registers increased by 21,878 in the London area, 21,050 in the Eastern area, 17,635 in the Southern area, 7,331 in the South-Western area, 17,017 in the Midlands, 20,516 in the North Midlands, 20,238 in the North-Eastern area, 13,957 in the North-Western area, 4,967 in the Northern area, 8,005 in Scotland, and 4,783 in Wales. The Southern area now includes the former Southern and South-Eastern areas.

At conferences in London last week which were attended by representatives of the Engineering and Allied Employers' National Federation, the Amalgamated Engineering Union, the National Union of Foundry Workers and the Engineering Joint Trades Movement, the claims of the trade unions for a wages increase of 10*s.* a week were further discussed. The meetings lasted for the greater part of a day, and, at their close, it was officially announced that the parties had decided to recommend acceptance of the following settlement terms to their constituent bodies :—(1) That the national bonus be increased by 5*s.* a week to all adult male workers, such increase to apply as from the commencement of the pay period starting in the week beginning February 19, 1940 ; (2) the wages of apprentices, boys and youths will fluctuate proportionately according to the national agreement of December, 1937.

In January, the home branch membership of the Amalgamated Engineering Union increased from 376,401 to 378,397, and the Colonial branch membership from 36,693 to 36,929. The number of members in receipt of sick benefit increased from 3,802 to 7,825, and the number in receipt of superannuation benefit decreased from 14,065 to 13,972. The number in receipt of donation benefit increased from 713 to 750, and the total number of unemployed members decreased from 3,723 to 3,427.

Writing in the February issue of the *Journal* of the Amalgamated Engineering Union, the editor says :—"The difficulties which confront the trade unions are not lessened by the mischievous Communist activities which are developing again in our Movement on the old familiar lines. Evidence accumulates of the existence of a furtive propaganda which aims at fomenting industrial unrest and magnifying every grievance felt by the workers with the object of disrupting the Movement's solidarity. We feel it necessary to warn our membership and trade unionists generally of the Communist Party's reversion to its former disruption and mischievous methods. . . . We hope our members throughout the country will be on their guard against Communist propaganda. Disturbing incidents have occurred to show that the old 'union smashing' tactics are again being employed by Moscow's agents in promoting unofficial strikes and intensifying local discontent."

"These natural enemies of freedom within our ranks," the writer goes on to say, "are perfectly aware that this union, annually or oftener, through its fairly appointed representatives, has effective machinery for determining policy, and the adherents of the programme of the Communist Party have taken their full share in shaping that policy. This has often resulted in directions to the executive council to enter into agreements with employers' federations. Why are these agreements not honourably observed ? Is the pledged word of the membership, acting through its elected officers, to be set aside when it suits the purpose of Josef Stalin and his admirers ? . . . The duty of all loyal members of the union is clear. The constitution provides for settling any differences without the advice of political adventurers."

An offer of increased wages made by the Railway Executive Committee on Thursday last week to executive representatives of the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Railway Clerks' Association was accepted at a meeting of the unions on the following day. The original claim of the N.U.R. and the A.S.L.E. and F. was for an advance of 10*s.* a week ; the R.C.A. asked for an increase of 20*l.* a year. Under the terms of settlement, the following flat rate additions are to be made to the wages of the conciliation staff covered by national agreements :—Men, 4*s.* a week ; junior males, 2*s.* a week ; women, 3*s.* a week ; junior females, 1*s.* 6*d.* a week. For clerical staff, stationmasters, and supervisory staff the increases are to be 10*l.* a year for men ; 5*l.* a year for junior males ; 3*s.* a week for women clerks ; and 1*s.* 6*d.* a week for girl clerks. These additions will be taken into consideration in calculating overtime, Sunday duty, and night duty payments, but will not be included in the calculation of superannuation allowances or pensions. The advances will include the cost-of-living additions which became payable on January 1. The cost-of-living sliding scale is to be suspended. Grades of railway staff not covered by the national agreements will be considered separately. The railway shopmen are covered by this announcement.

Commenting on the agreement, Mr. Marchbank, the general secretary of the National Union of Railwaymen, said that it established the principle of a uniform increase of wages for all grades on account of the increase in the cost of living consequent on the war. Men who would not have been entitled, under the sliding scale now suspended, to any increase until the index figure went up in some cases to 75 and in others to 115 would now receive advances. As the additional payments would be included in the basis for the calculation of overtime, Sunday duty, and night duty rates many men would in fact receive 5*s.* or 6*s.* a week extra.

It is stated that the recommendation of the national delegate conference of the Mineworkers' Federation of Great Britain to accept the proposed sliding scale for the wartime adjustment of wages has been endorsed by the district associations. There are to be quarterly adjustments of the war addition to wages in which seven-tenths of a penny will be allowed for each point of variation in the cost-of-living index figure. No account will be taken of variations of less than five points.

Mr. Bevin claims, in the course of an interesting article in the February issue of the *Transport and General Workers' Record*, that the policy of his union is "a constructive one." "Before the war," he says, "we were seeking to establish a new minimum basis over a wide area of industry, and in no case was this basis lower than 3*l.* for the standard week. In many cases it was higher. In addition to fixing a minimum, we were re-grading much of the work so that many classes of members who had, in the past, been upon the minimum and whose wages had never been fixed either in accordance with their skill or output or the nature of their work, would be raised to higher rates. In other words, we have for several years been constructing new wage structures over a wide range of industries."

"This was being reflected," Mr. Bevin continues, "in a real improvement in the standard of life, for, the wages and standards were being increased at a time when the actual cost of living, in terms of food, was falling. Falling prices and increases in wages were producing a new standard of life, and causing an increased demand in the country for the products of the newer industries which are expressed in terms of 'amenities.'"

Recent administrative Orders issued in Germany state that since "the transitional period of adaptation to new conditions has now passed," the protection of women workers must again be intensified. The extension of hours of work up to ten in the day, allowed in urgent cases by the Order of September 11, 1939, is not, as a rule, to be applied except in cases of important armament orders, export orders that must be carried out without delay, or work essential to ensure the nation's food supply, and only when it is impossible to find the necessary additional labour to perform the work. The employment of women for more than ten hours in the day is allowed only by special permission, in very exceptional circumstances. Rest periods may not be shortened if the work requires considerable physical effort or is performed in difficult conditions, even if the nature of the work involves frequent short interruptions. In the case of married women, and especially mothers of families, the inspection authorities may order a reduction of hours of work on certain days of the week to enable these women to see to their households, obtain ration cards and do their shopping. As an example, it is suggested that married women should be allowed one day's holiday every fortnight.

The exception to the prohibition of night work allowed by the Order of September 11, 1939, for work in regular alternate shifts is still preserved ; but other exceptions to the prohibition are allowed only temporarily, in cases of *force majeure* and, with special permission, in exceptional circumstances. Before authorising exceptions, the authorities must consider whether establishments working two shifts could not introduce a third night shift on which women would not be employed.

The employment of young persons in Germany is also governed by a series of Administrative Orders. Hours of work may not, as a rule, exceed eight in the day ; the exceptions allowed are the same as in the case of women. Any extension of the hours of work must not be prejudicial to the vocational training of young persons. The shortening of rest periods is subject to the same restrictions as in the case of women. As far as possible, young persons must have Saturday afternoons off. The exceptions to the prohibition of night work are the same as for women ; young persons may be employed at night only in urgent cases, or if their employment on morning or evening shifts is closely connected with the employment of adult workers.

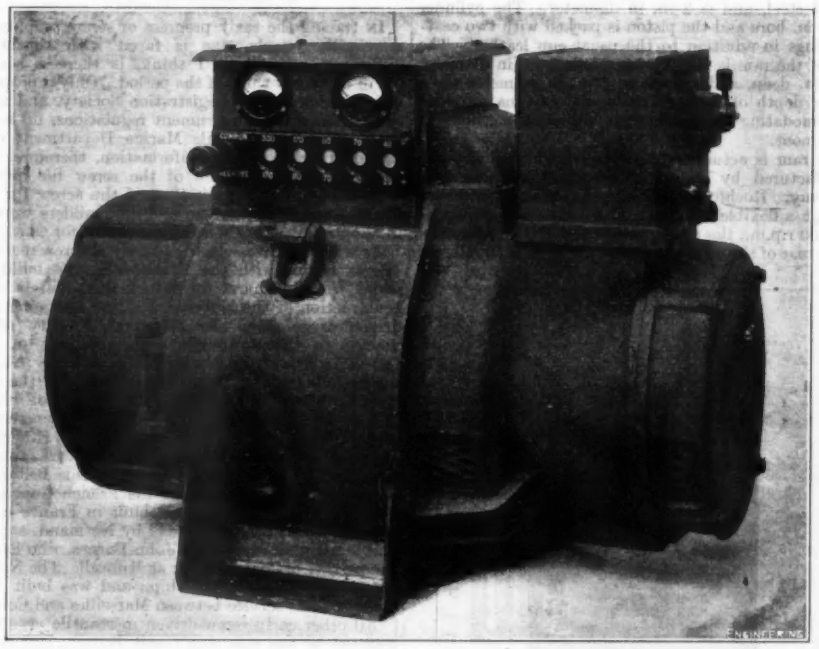
An Order issued on August 29, last year, by the Japanese Minister of Social Welfare, gave the holders of mining concessions the right to employ women over 25 years of age on underground work until March 31, 1942, provided that they obtained special permission from the director of the Mines Inspection Department. Up till then, young women who had reached the age of admission to employment could be engaged on underground work in mines on light work consisting mainly on picking up pieces of coal.

Taking into account wishes expressed by the Superior Labour Council attached to his Department, the Minister of Social Welfare, at about the same time, sent a circular to the heads of mining inspection offices instructing them not to grant permission for the employment of women underground except in cases where male labour was absolutely unobtainable. It also laid it down that such permission was not to be granted in the case of coal mines producing large quantities of gas or coal dust nor of any other mine where the work was of an unhealthy or dangerous nature. As a rule, women employed underground must be the wives of miners who are also employed underground. Any dismissal or transfer of a woman from one workplace to another must be reported to the inspection authorities without delay. Night work was strictly prohibited, and it was insisted that employment was to be so organised as to ensure the full application of all the other statutory provisions for workers' protection in regard to rest periods, health, nutrition, etc.

UNITED STATES MID-WEST POWER CONFERENCE.—For the third consecutive year, the Armour Institute of Technology, Chicago, is organising a Mid-West Power Conference with the co-operation of the Iowa State College, the Universities of Illinois and Michigan, and other universities and colleges, and several national and local engineering and technical institutions in the Middle-West area. The Conference will take place at Palmer House, Chicago, on Tuesday and Wednesday, April 9 and 10. Starting at 10 a.m., the whole of the first day will be devoted to the presentation and discussion of papers on gas turbines, Diesel and steam-engine drives for small power plants, problems of electrical transmission and distribution, and the supply of power for paper mills, in refineries and chemical plants. On the morning of the second day the questions to be discussed will comprise the fuel problems of power plants (including coal, pulverised-fuel and gas firing) and hydro-electric power stations. Visits and excursions have been arranged for the afternoon.

DROOPING-CHARACTERISTIC WELDING GENERATOR.

MESSRS. J. H. HOLMES AND COMPANY, LIMITED, HEBBURN-ON-TYNE.



DROOPING-CHARACTERISTIC WELDING GENERATOR.

THE sequence of operations in the deposition of metal by means of the electric arc, namely, striking, welding, and breaking, prescribes the requirements of the supply. For striking, the voltage should be high enough for the working conditions; during welding it should adjust itself to the lower value required to maintain a stable arc; and it should recover rapidly when the arc is broken, to enable re-striking to take place. One of the earliest methods, and certainly the simplest, of obtaining a supply suitable for arc welding, was to use a constant-voltage circuit with a resistance connected in series with the electrode. This resistance not only provided the necessary droop in voltage between the striking value and the welding value, but also, being non-inductive, enabled the voltage to respond rapidly to changes in arc-length, and thus kept the current stable. This method is still used where a number of operators work from the same source of supply, and it enables full advantage to be taken of diversity in time and current. For single-operator working, however, it is preferable to use a generator having its inherent regulation arranged to provide the requisite droop in voltage at the arc without the aid of a control or ballast resistance, as the consequent saving leads to more economical running. It is evident, however, that a drooping-characteristic generator cannot be used for multi-operator working since the interference produced between operators would render stable working impossible.

The problem of the electrical designer is to produce a generator that, in addition to providing a drooping characteristic efficiently, is also capable of rapid response to the fluctuations in the arc; that is to say, not only must the output voltage be made to vary automatically from striking-value to welding-value (this relationship is often spoken of as the static characteristic), but the transient characteristics under welding-conditions must also be carefully considered, if satisfactory results are to be obtained. The transient, or dynamic, characteristics, as they are often called, essential to good performance can be summarised as follows:—The current should rise rapidly when the arc is struck, but should not overshoot the setting value to an excessive extent, since this causes the electrode to stick to the work. Some overshoot is helpful, however, in giving a good start to the welding operation. The current should remain stable with varying arc-lengths to ensure smooth operation. This depends largely on the rate of voltage-response to changes in arc-length. The output-voltage should recover rapidly from short-circuit or welding conditions, so that it is immediately available to maintain or re-strike the arc. The essential features of a good welding generator, stated above, are not necessarily independent of one another, and a point of major importance in design, affecting all these requirements, is the rate of excitation-response to changes in welding conditions.

The welding generator shown in the accompanying illustration has recently been placed on the market by Messrs. J. H. Holmes and Company, Limited, Hebburn-on-Tyne. It uses third-brush excitation, and the necessary drooping-voltage at the arc is produced mainly without the use of series resistance. The generator has two main poles and two large auxiliary poles, which are arranged in twin groups, as well as a two-pole armature. On open-circuit all the poles are worked at high density, but on load armature reaction tends to strengthen the main poles and to weaken the auxiliary poles. Since the main poles are saturated, however, the net effect is a reduction of the electromotive force, and the required drooping characteristic is obtained.

To ensure rapid excitation response, the generator is provided with a laminated field, which reduces to a minimum the eddy-currents in the magnet that would normally have a damping effect on the flux-change. An additional feature of the generator is the use of forward or compounding series-windings, the effects of which are well-known to be beneficial because when current is interrupted in the welding-circuit electromotive forces are induced in the associated shunt-windings, and these aid rapid recovery to open-circuit conditions. Forward series-windings are fitted on all the poles, but the helpful mutual-inductive effect is greatest in the main poles. The shunt-windings are therefore, interconnected so that the shunt-circuits as a whole have positive or helpful electromotive forces induced in them when the welding-current is interrupted. This allows the resistance-drop to be reduced to a minimum, and leads to high efficiency.

As will be seen from the illustration, the general construction of the generator is compact. The control box is small and is provided with simple means of current-selection. Five plug connections give the full current range of 300 amperes to 20 amperes, and from 300 amperes down to about 70 amperes no series resistance is used. For currents from 70 amperes to 20 amperes, however, series resistance is introduced in two steps, since this is regarded as the most satisfactory form of control for small currents. An appreciable saving in weight has been achieved by more efficient utilisation of active material, and this is obviously advantageous in the case of portable equipment. All the well-tried features of previous types of welder made by the firm are retained, including strong construction, rigid brushgear, a liberally-designed commutator, and accessibility for inspection and maintenance. The new welder is made in various patterns for both stationary and mobile work, and for different conditions of operation. The generator can be driven either directly or by belt from an internal-combustion engine, or by an alternating-current or direct-current motor. Twin-generators can also be accommodated in a common frame, either for two operators or for one operator at double output. The welder is suitable for use with fully-fluxed, dipped or bare-wire electrodes from No. 2 to No. 18 S.W.G., or with carbon electrodes for light-gauge welding, treatment of steel castings, or other similar purposes.

Other single-operator Holmes sets are available in sizes ranging from a 50-ampere light-current welder, specially designed for light-gauge sheet-metal work, to a 425-ampere heavy-current welder suitable for welding shops engaged on heavy work. In addition, a range of constant-voltage multi-operator sets is available, designed to supply current to 2, 5, 10, 36, or 80 operators. Up to the size for 10 operators, the sets are of the level-voltage compound-wound type, and are suitable for welding-shops of various sizes or for use as portable or semi-portable units in shipyards. The still larger sets are of the automatic voltage-regulated type and are particularly designed for shipyard use. A special feature of the two-operator equipment is that it employs a divided-circuit construction, which eliminates interference between the two operators. This is also available in the five-operator equipment to enable it to work as a heavy-current two-operator set.

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, NEW YORK.

(*Concluded from page* 150.)

EXPERIMENTS ON FORM RESISTANCE.

CAPTAIN E. F. EGGERT (CC), United States Navy (retired), in his paper on "Further Form Resistance Experiments," reported on a continuation of experiments, previously described before the Society, on the frictional resistance of a ship's form. The model used, No. 3383, was 20 ft. in length, and had shaft bossings for twin screws and a pronounced bulb forefoot. It was provided with more than 300 $\frac{1}{16}$-in. orifices for connection to a manometer, having 30 glass scale tubes, for the measurement of pressures at selected points. Both towed and self-propelled runs were made. The residual resistance was found to be less than the form resistance over the greater part of the speed range, and especially over the part in which frictional resistance was predominant, or at least important. As the principal difference between the model tested and the normal ship form was in the bulb, it was thought possible that the bulb in some way affected the flow so as to reduce the average speed of the water behind it along the hull. At the top speed, however, this condition was reversed, suggesting that the action of the bulb might change with the speed. That the bulb did act, in some way due to the high pressure on its face, to reduce the general resistance of the vessel was indicated also by a test made after streamlining it with a pointed cap. The results showed that the method of testing was practicable, but laborious and by no means commercially feasible. The frictional resistance of a model might differ from that computed by the standard method, on account of some peculiarity of form, and might be either less or greater than the amount so computed; but there was at present no reliable way to determine what change should be made in the standard method. The augmented resistance of a model, when self-propelled, was only partly a pressure phenomenon; the increased velocity of the water along the afterbody, due to the propellers, must cause some increase of frictional resistance, as well as eddy resistance, especially on the appendages.

MERCHANT MARINE PERSONNEL.

The eighth paper in the programme, entitled "Some Observations Regarding Merchant Marine Personnel," by Professor H. L. Seward, of the Faculty of Mechanical and Marine Engineering at Yale University, was quoted to some extent in a leading article in ENGINEERING of December 29. The following summary deals more particularly, therefore, with those portions of the paper with which we have not already dealt. Professor Seward introduced his subject by comparing the industrial evolution of the United States with that of England from the Eighteenth Century onward, and emphasised the effect that the more rapid development in America had had upon the social amenities enjoyed by the American workman. "Big business" had progressed no less remarkably, and he suggested that, perhaps, the nation had become over-developed in some respects. In marine transportation, he thought, "the injection of the Government into the picture had not yet been as beneficent as the dreaming idealists professed." Government operations in industrial matters were never efficient, flexible, nor truly in accord with fundamental business enterprise. In addition to "a complicated group of laws, convention requirements, regulations and rules as a basis of activities for a large number of Governmental units in contact

with the maritime industry," there was "an intricate and involved system of supervision in the hands of the Government for controlling the physical characteristics of ships and the attributes and performance of personnel afloat." Too often the tendency was "to freeze into legislation the present state of the arts or the practices of management. The laws should state standards, limits or types of controls, but not the technique nor details to be followed." After reviewing the stages which led up to the report to Congress, in January, 1939, on *Training Merchant Marine Personnel*, Professor Seward proceeded to a survey of the work accomplished to date by the four State nautical schools and the methods of licensing and certifying personnel, and commented that "reports indicate that . . . the men now comprising our merchant marine are better trained, more experienced and increasingly better fitted for their tasks in all respects save one—the attitude of crewmen toward their superior officer." The legend should be scotched, however, that seamen were simply rough, improvident wanderers; the modern vessel was no place for such men, and the seaman to-day was almost always of a higher type. It seemed intolerable that, in labour disputes, a solution to the problem of true understanding between men and management could not be found except by the long and costly attrition of the ancient "survival of the fittest" doctrine. Perhaps some owners, looking in retrospect, would realise that they had waited a little too long before giving attention to the needs of the men; but the owner still was responsible for the efficient and safe operation of ships and terminals, and must retain the authority to reject and dismiss the proved incompetent.

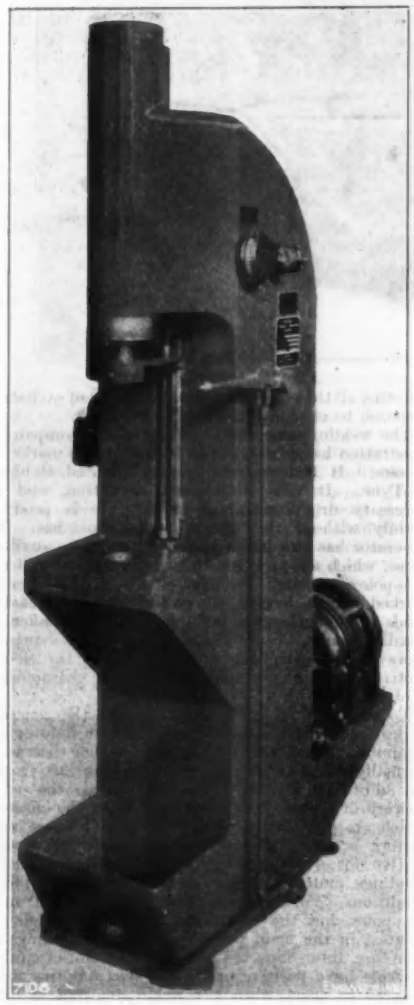
The Economics of Super-Liners.

The concluding paper presented at the meeting, by Mr. George C. Gaede, consisted mainly of comparative operating statistics in favour of the assertion embodied in its title, "American Super-Liners—They Will Pay!" The people of the United States, Mr. Gaede claimed, normally spent about 500 million dollars annually in foreign travel, and only 5 per cent. of this sum would be required to sustain two super-liners remuneratively. The first vessel to be classed as a "super-liner," he considered, was the Berengaria (ex-Imperator), built as the result of the late Albert Ballin's decision to construct the largest liner that could be accommodated in the ports between which she was to ply. The super-liners operating from United States ports between 1928 and 1938 made 2,171 voyages in that period, and carried 25·87 per cent. of the 7,502,566 passengers transported. The total revenue earned by the Queen Mary alone, in the three years, June 1, 1936, to June 1, 1939, he estimated at more than 36 million dollars, for a gross operating expense, exclusive of interest on the Government loan for her construction, of about 25,336,000 dols. Based on this performance, her average earnings per year, for 20 years, should show an annual profit of nearly four million dollars. If employing only 35 per cent. of her passenger capacity, for 22 voyages in the year, she should still show a profit of nearly 100,000 dols. From 1929 to 1938, inclusive, the Bremen and Europa together carried 677,039 passengers. American-built super-liners would cost about 60 million dollars each, and might be expected to carry about 66,000 passengers per ship per year, at 60 per cent. of their full capacity. Taken on the same basis as that of the Queen Mary, the total revenue from two such ships should be about 28 million dollars per annum. There was no reason why America should not carry at least half of the Transatlantic traffic; but it was important, in all larger ventures, that they should be properly timed. It took about three years to build a super-liner. In three years, the business of the world should be again upon the high road; he believed, therefore, that the time to build was the present, so that the ships could be placed in service on the next upswing of business.

TWO-TON VERTICAL HYDRAULIC PRESS.

The two-ton vertical hydraulic press shown in the accompanying illustration has been recently introduced by Messrs. American Broach and Machine Company, Ann Arbor, Michigan, U.S.A., as a handy machine for operations requiring pressure, such as assembling parts which have to be a tight fit in one another, dismantling such parts, straightening processes, and both internal and external broaching. Although the normal working load is 2 tons, a pressure of 4 tons can be obtained when desired. Its capacity, as regards size of work that can be dealt with, may be gauged from the facts that the maximum distance between the nose of the ram and the surface of the table is 14½ in., this dimension also being the stroke of the ram. The table surface is 8 in. by 10 in., and it has a central hole 2¾ in. in diameter. This hole is bored at the same time as the cylinder, and, as the whole body of the machine, including the table bracket, is a single casting, the alignment of the cylinder bore and table hole always retains its accuracy. The distance from the ram centre line to the stop bar on the column face is 5¼ in. The ram is of hardened and ground steel, and is 2 in. in diameter. The cylinder is of 4 in. bore and the piston is packed with two cast-iron rings in addition to the usual cup leather. The nose of the ram is bored with a hole ¾ in. in diameter by 1 in. deep, and tapped to ¾ in. in diameter for a further depth of 1 in., the alternatives thus provided accommodating tools requiring different methods of attachment.

The ram is actuated by oil delivered from a pump manufactured by Messrs. Sundstrand Machine Tool Company, Rochford, Illinois, U.S.A., and driven through a flexible coupling, by a 3-h.p. motor running at 1,200 r.p.m., the motor being mounted on a bracket at the rear of the column. The pump itself is submerged



in the oil which forms the working fluid, the oil being supplied from a reservoir in the top of the column having a capacity of 17 gallons. The movement of the ram is controlled either by pedal or hand-lever, the two being connected by a link, and actuating a valve. Movement of the pedal or lever downwards is followed by movement of the ram in the same direction. The load on the ram is maintained as long as the pedal or lever is depressed, but as soon as either is released the ram returns to the top neutral position. The stroke of the ram can be adjusted by means of stops on a rod on the face of the column, the stops being actuated by a bracket on the end of the ram. The speed of the ram on the down stroke is 31 ft. per minute, and on the up stroke 41 ft. per minute. The normal operating pressure is 320 lb. per square inch, the maximum pressure being 640 lb. per square inch. The pressure is recorded on the quadrantal dial gauge seen above the hand lever. A simply-adjusted relief valve enables the pressure to be set to any desired amount within the maximum load. The machine has an overall height of 6 ft. 5¼ in., an overall depth from front to back, including the motor, of 4 ft. 2½ in., and an overall width of 18¼ in. When required, a cooling-fluid pump can be supplied, belt-driven from the motor shaft.

THE FIRST TWENTY YEARS OF SCREW PROPULSION.*

By Eng.-Capt. Edgar C. Smith, O.B.E., R.N.

(*Concluded from page* 127.)

In tracing the early progress of screw propulsion in mercantile vessels, one is faced with considerable difficulties. Nowhere, I think, is there a complete list of the screw ships of the period. Only a proportion were classified by a Registration Society, and though there were many Government regulations, up to 1854 there was no Mercantile Marine Department of the Board of Trade. Much information, therefore, is not available. The problem of the screw for merchant ships was different from that of the screw for naval vessels, and if shipowners and shipbuilders were slow in adopting it, there were good reasons for caution.

As with naval vessels, the history of screw mercantile vessels begins with the Archimedes, the building of which led Wimshurst to embark immediately on the construction of the Novelty, the first sea-going screw-driven cargo ship. In 1841, the Novelty made a voyage to Constantinople with 420 tons of cargo. On June 16 of that year, *The Brighton Guardian* recorded a trip up the River Arundel by the screw-driven pleasure steamer Princess Royal, of 101 tons and 46 h.p. In 1842, *The Nautical Magazine* noted as already built the Archimedes, Novelty, H.M.S. Bee, Princess Royal, and the Beddington (27 tons and 60 h.p.), and, as building, the Great Britain, the Rattler, and two vessels for the French Government. The first screw-driven vessel built in France was the Napoleon, constructed in 1842 by Normand, at Havre, and fitted with engines by John Barnes, who had been the partner of Joseph Miller at Millwall. The Napoleon was of 364 tons and 120 h.p., and was built for the postal packet service between Marseilles and Corsica.

All other early screw-driven mercantile vessels were eclipsed by the iron ship Great Britain, laid down at Bristol in 1839, launched in 1843, and completed in 1845. One of her constructors, Thomas Richard Guppy, on December 18, 1843, secured a Patent No. 9779, for "Certain Improvements in the Building of Metal Ships and other Vessels," in which he described the cellular construction much as Scott Russell and Brunel used it in the Great Eastern twenty years later. Guppy's invention seems to have escaped notice by writers on the construction of iron ships. The Great Britain was the first screw ship to cross the Atlantic under steam.

The year 1845 was also marked by the construction at Dumbarton by Peter Denny (1820-95) of the Waterwitch, the first commercial screw-driven vessel built on the Clyde; and by the construction at Liverpool of the Sarah Sands. The latter was designed by John Grantham (1809-74) and was one of the earliest auxiliary screw trading vessels. At the first dinner of the Institute of Marine Engineers, in the Holborn Restaurant on May 20, 1891, Denny made some interesting remarks about his experiences when building the Waterwitch. "When we undertook the Waterwitch," he said, "we knew little about screw steamers. . . . We applied to Mr. Smith (afterwards known as "Screw" Smith), the patentee, who supplied us with information and gave us plans for the construction of the screw aperture, etc. Viewed in the light of subsequent practice, the construction of this aperture was a curiosity. . . . The stern post was made like that of a sailing ship, but with an upright piece about 2 ft. forged on to the keel part of it, where the forward side of the screw aperture was to be. . . . This piece was scarfed to receive the inner post, which was precisely like a tuning fork made in two parts. This was carried up straight the height of the aperture, and then bent back to take hold of the stern post. To the inner-outer edges of this forked post were riveted angle irons, to which was again riveted a plate through which, at the throat of the tuning fork, was the hole for the propeller shaft. This plate again had angle irons riveted to it for receiving the ends of the shell plating. The after end of the propeller shaft worked in a cast-iron boss bolted to the stern post. Less than a year after this, forged inner and outer posts took the place of this peculiar structure. I may mention that Mr. Smith appointed us agents for his patents on the Clyde district, but I am sorry to say we never got a penny of royalty for him."

What appears to have been the first shipping company started to maintain a fleet of iron screw cargo ships was Messrs. The General Screw Steam Shipping Company, which existed from about 1847 to 1857. Most of the ships of this company were built by J. C. Mare (1815-98) at Blackwall and engined by Maudslays, and a few of them were fitted with the feathering screw invented by Joseph Maudslay. R. A. Robinson, in

* Paper read at a meeting of the Newcomen Society, held at the Institute of Marine Engineers, London, on January 17, 1940. Abridged.

SAFETY DEVICE FOR FALLING PERSONS.

MR. J. W. SCHERRER, HEERLEN, HOLLAND.

Fig. 1.

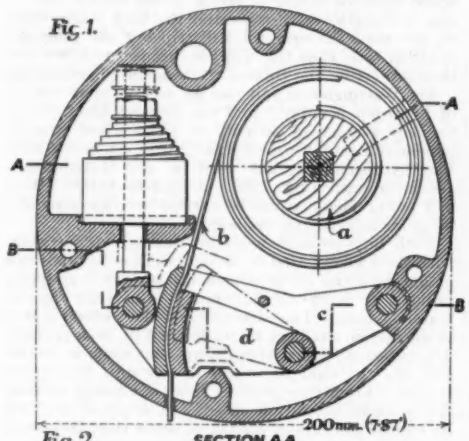


Fig. 2. SECTION AA

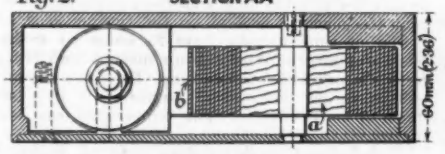


Fig. 3. SECTION BB

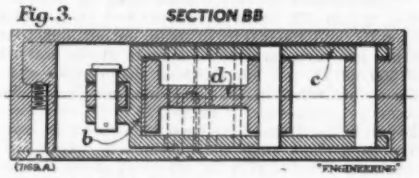


Fig. 4.

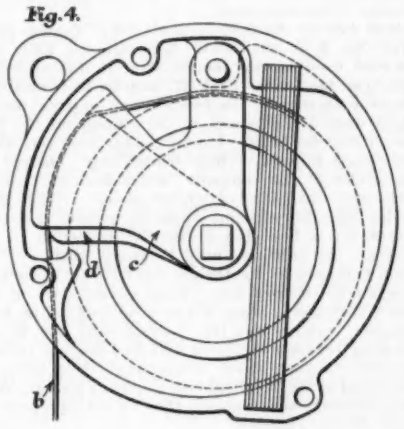
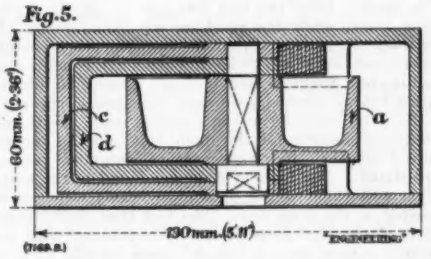


Fig. 5.



his paper of 1855,* said that the earliest successful commercial examples of screw-propelled freight vessels were the Earl of Auckland, City of London and Lord John Russell of this company. Originally formed to run vessels between London and Holland, later on they sent vessels to Constantinople, the Cape of Good Hope, Calcutta and Australia. Included in the fleet were the ships shown in Table I, below.

On January 1, 1850, James Laming, the managing director of the company, wrote a letter to the *Morning Chronicle*, in which, after referring to the project of steam navigation to Australia, he gave particulars of the voyages made in 1849 by the five smaller ships

TABLE I.—*Vessels of the General Screw Steam Shipping Company.*

Date.	Name.	Tonnage.	Horse-power.	
			Nominal.	Indicated.
1845	City of Rotterdam ..	270	30	
,,	City of London ..	270	30	
,,	Lord John Russell ..	320	40	
,,	Sir Robert Peel ..	320	40	
1848	Earl of Auckland ..	450	60	
1849	Bosphorus*	531	100	
,,	Hellespont	531	100	
,,	Propontes	531	100	
1851	Harbinger*	920	150	620
,,	Queen of the South ..	1,752	300	752
,,	Lady Jocelyn ..	1,752	300	800
,,	Indiana	1,752	300	800
,,	Calcutta	1,000	300	800
1852	Argo*	1,800	300	818
1853	Golden Fleece* ..	2,500	300	900
	Jason	2,867		
	Hydaspes	2,248		

* Fitted with feathering propeller.

of the company. They had made 170 voyages outward and homeward, making good a total distance of 110,849 nautical miles at an average speed between 8 knots and 8½ knots. In July, 1850, *The Times* published an article on the Admiralty invitation to tender for the conveyance of mails to the Cape by steam. The ships were to be screw-driven, with engines of not less than 200 h.p.; the speed was to be not less than 8 knots. The opinion was expressed that the service would settle the question of the suitability, or otherwise, of the screw for long voyages. The contract was given to the General Screw Steam Shipping Company, and on December 16, 1850, the Bosphorus left Plymouth to inaugurate the service. Her sailing was the occasion of much rejoicing, as it marked the opening of the port as a Government mail-packet station. The Harbinger was built in an unusual manner, for a part of her consisted of a section of H.M.S. Recruit, the only iron sailing vessel built for the Royal Navy. According to Henry Maudslay, who spoke in the discussion on Robinson's paper, the feathering screw was found most useful. It could easily be feathered or unfeathered without stopping the ship's way. The venture of sending the vessels to the Cape, unfortunately, proved unprofitable, and during the Crimea War some of the ships were used as transports. In 1854, the Argo made a voyage to Australia and was the first screw-driven vessel to circumnavigate the globe. By 1856, the company was in difficulties and in the following year the ships were put up for auction. According to D. B. Tyler, the author of *Steam Conquers the Atlantic*, an American company was formed to take over the larger vessels and run them between Bremen and New York.

Though the Great Britain, the Sarah Sands and one or two other screw ships made a few passages across the Atlantic between 1845 and 1850, the credit for establishing a regular service with such ships belongs to the Clyde shipbuilders, David Tod and John Macgregor, and the shipowner, William Inman. In 1850, Tod and Macgregor laid down and completed the iron ship City of Glasgow, of 1,670 tons and 350 nominal horse-power, having accommodation for 137 first-class and second-class passengers, 400 steerage passengers, and 1,200 tons of cargo. In 1850, she made the passage to New York in 14 days. She was almost immediately bought by the Liverpool and Philadelphia Steam Ship Company, organised by Inman, and thus became the first ship of the famous Inman Line. For this company, Tod and Macgregor next built the City of Manchester. The engines of these vessels were similar to the familiar Watt land engine, with vertical cylinders and overhead beams, and were geared to the propeller shaft. The City of Glasgow disappeared with all hands in March, 1854. In 1855, the company obtained the City of Baltimore (1,224 tons gross) and the City of Washington (1,618 tons gross), both vessels having geared steeple engines.

The earliest screw vessels of the Cunard Company were iron cargo ships. When giving evidence before a Parliamentary Committee on Atlantic Mail Steamers in 1849, when the Admiralty still required subsidised mail steamers to be built of wood, Samuel Cunard stated that "for long voyages, paddles unquestionably are the best; there can be no doubt upon the subject." Between 1852 and 1854, however, Cunard obtained the four iron screw cargo ships Alps and Andes, of 1,400 tons, and the Aetna and Jura, of 2,190 tons; and in 1861, the China, the company's first iron screw passenger vessel, was added to the fleet.

Table II, herewith, gives particulars, in chronological order, of the early screw ships of the Peninsular and Oriental Steam Navigation Company, the data being taken from Mr. Boyd Cable's history of the company.

Of these vessels, the Himalaya was by far the most notable. She did good work as a transport in the Crimea War and was then added to the Royal Navy. The Chusan lives in P. and O. history for her voyage to Australia via the Cape. She left Southampton on May 15, 1852, and reached Melbourne on July 29. Her arrival raised the greatest enthusiasm and was regarded as "a long-delayed triumph for those who had fought for years for a regular mail service."

TABLE II.—*Early Screw Vessels of the P. and O. Company.*

Date.	Name.	Gross Tonnage.	Horse-power.	Type of Engines.
1851	Shanghai ..	546	100	Oscillating.
1852	Chusan	699	80	,,
,,	Madras	1,185	754	Beam, geared.
,,	Formosa ..	675	80	Vertical.
,,	Bombay ..	1,186	750	Beam, geared.
1853	Bengal	2,185	1,084	Beam, geared.
,,	Cadiz	816	450	Trunk, geared.
,,	Rajah	537	120	Trunk, geared.
,,	Douro	810	54	Steeple, geared.
,,	Norna	969	624	Steeple, geared.
,,	Himalaya ..	3,438	2,050	Horiz. trunk
,,	Manilla	646	290	Trunk, geared.
,,	Colombo ..	1,864	450	Beam, geared.

Another screw vessel which made the same passage in 1852 was the Australian, built at Dumbarton for the Cunard Company, but sold for the Australian mail service. Her voyage out and home was very protracted. She left Plymouth on June 5, 1852, and did not reach home again until January, 1853. One of the problems which faced the owners of steam ships making these long voyages was that of providing coal depots at suitable ports.

Finally, the following figures will give a general idea of the relative position of both paddle-wheel ships and screw ships in our Mercantile Marine at approximately the end of the period:

Of the total number of steam vessels registered by the Board of Trade up to January 1, 1857, there were 820 wooden vessels with paddle wheels and 19 with screw propellers, 356 iron vessels with paddle wheels, and 473 with screw propellers. According to *Mulhall's Dictionary of Statistics* (1885), in 1840 the tonnage of British sailing vessels was 3,216,000 tons, and of steam vessels 95,000 tons; in 1860, these figures were respectively 5,211,000 tons of sailing ships and 502,000 tons of steam ships. By 1860, iron ships and screw propellers were fast superseding wooden ships and paddle wheels.

SAFETY DEVICE AGAINST SHOCK TO FALLING PERSONS.

THE problem of safeguarding persons whose work is carried on at a dangerous height from the ground is not quite so simple as it might appear at first sight. Safety belts and harness with a rope attached to the building or scaffolding concerned, while preventing a fall to the ground, very often causes injury by the sudden arrest of the falling person when the "slack" necessary to allow him to carry out his duties has been taken up. Mr. J. W. Scherrer, Bureau Mÿnwezen, Heerlen, Holland, on behalf of the Inspection of Mines Department of that country, has lately perfected two safety devices which absorb the momentum of the falling person gradually and so cause arrest of movement without shock. We understand that these devices have recently been thoroughly tested and have proved satisfactory. Mr. Scherrer used as a basis of his experiments the momentum arising from a man weighing 75 kilos (about 11·8 stone) falling from a height of 2 m. (about 6 ft. 7 in.), and came to the conclusion that no existing device provided a really satisfactory safeguard.

The larger pattern of the new design is shown in Figs. 1 to 3, on this page. It consists of a light cylindrical casing with a cover attached by screws and having a hole through both at the top for the attachment of the device to the scaffolding, etc., on which the man may be working. The upper part of the box contains a wooden barrel *a* mounted on a steel spindle and holding a coil of steel tape. This latter forms the suspending part of the gear and the man is attached to it by a suitable belt. The tape is indicated at *b* and near the point of emergence from the casing passes between a pair of quadrantal surfaces. Both these surfaces are formed at the free end of pivoted levers *c* and *d*, the fulcrum of lever *c* being on the casing and that of lever *d* being on lever *c*. This device forms a brake which is automatically applied, increasing pressure on the tape up to a predetermined amount. As shown, the two levers are in the position they occupy

* *Proc.Inst.C.E.*, vol. xiv, page 375 (1855).

when a man is suspended by the tape, the lever *d* being held down, by the load on the tape, in contact with a stop. But the lever *c* resists the load on the tape by means of the coiled spring seen to the left. Had the lever been held and only lever *d* been free, the inevitable result would have been that the tape would have been suddenly jammed as it ran out, and the resulting jerk would have defeated the object of the device in eliminating shock while the tape might have snapped. As it is, on the fall of a man the two levers first move downwards, from the dotted position of lever *c*, and apply a smoothly increasing pressure on the tape as the arc of contact becomes greater during the descent of the levers.

As already stated, however, a complete lock does not occur when lever *d* comes up against its stop. Instead, the differential movement of the levers and the strength of the coiled spring are so designed that the tape continues to slip through the levers for a certain distance until the remaining momentum of the fall is absorbed by friction, the amount of slip depending on the weight of the man and the amount of slack with which he was working. The retarding action is smooth and positive. The position of lever *c* when no load is on the tape is indicated by the partial dotted outline at the left. The position of lever *d* under no-load conditions is not, however, indicated by its corresponding dotted outline, as this merely shows how its upward movement relative to lever *c* is limited by a stop. The tape in the no-load position is in contact with the top edge of lever *c* and the bottom edge of lever *d*, and when it begins to move downwards it pulls the two levers together. The tape can be freely wound on to the barrel in the no-load position, the barrel spindle being provided with a square recess for the insertion of a winding key. The tape is kept from slipping off the barrel by a rib on both the casing and the cover, as shown in Figs. 1 and 2.

The smaller pattern of the shock-breaker is shown in Figs. 4 and 5. It has been designed where a light and compact fitting is imperative. Thus, it is applicable to parachute descents in which, as is well known, a severe jerk occurs when the parachute opens. The principle of the small device is identical with that of the large one, in that the tape is gripped between two quadrantal levers, but the coiled spring is replaced by a pair of flat laminated springs against which lever *c* bears, the same reference letters being used for both patterns. This lever is free to swing on the fulcrum visible at the top of Fig. 4, and lever *d* is pivoted on it at the apex of the triangle formed by the centre lines of its two halves. There are some minor differences in construction which will be evident from a comparison of the two designs; for example, the barrel in the small pattern is a light casting and the suspending lug is external to the casing.

EXPERIENCES WITH HIGH-TEMPERATURE HIGH-PRESSURE STATIONS.

At the annual meeting of the American Society of Mechanical Engineers, held in New York, in December, 1938, a number of papers were presented dealing with operating experiences with various high-temperature, high-pressure power-station installations, which had been set-up in the United States not long previously. We dealt with these papers and with the discussion on them in a leader in our issue of October 14, 1938, and reprinted the paper dealing with the experiences at Detroit in our issues of January 6 and 13, 1939. A further discussion on this subject took place at the annual meeting of the Society in Philadelphia in December, 1939. We give below abstracts of the papers presented on that occasion.

High-Pressure, High-Temperature Superimposed Installations at Waterside Station.

By J. C. Falkner.

There have been few changes in operating procedures at the Waterside Station since the installation of the high-pressure units two years ago. Such changes as have occurred have dealt mainly with the method of make-up, the method of watching water levels, chemical feed, sampling of boiler water, and the taking of steam samples.

It has not been possible, due to load conditions, to operate without some low-pressure boilers in service. A test of short duration with the high-pressure and low-pressure turbine units running without low-pressure boilers was made to check the operation of the back-pressure regulator on No. 4 turbine and to familiarise the operating personnel with the difficulties to be expected when excessive swings occur. The tests proved very satisfactory. Loads were varied on both high- and low-pressure units without difficulty. An operating procedure has been worked out so that, as soon as conditions permit, all low-pressure boilers will be shut down. The distribution of load between the high- and low-pressure units will be made by the switchboard operators. In case of loss of low-pressure load, the back-pressure regulator will automatically reduce the load on the high-pressure units but, in case load is lost on a high-pressure unit resulting in a reduction of low-pressure steam, the operator will reduce the low-pressure load to a point where the low-pressure steam is normal.

High-Pressure Turbo-Generator Units.—Turbine generator No. 4, a 50,000-kW Westinghouse unit, was removed from service shortly after it was placed in operation, September 10, 1937, in order to permit that company to remove the two rows of impulse blades. There were a few cracks in the shroud on the first row of impulse blades, but in neither row were there any blade failures. These blades were removed on the advice of the company, which had had trouble with other machines of similar design. With these blades out, this machine operated without difficulty, except for a few shut-downs for inspection of the governor and bearings, until February, 1939.

On February 10, the turbine was taken out of service to examine the bearings. Upon examination, it was found that the bearing in the head end of the high-pressure turbine and the bearing near the flexible coupling between the main and feed-heating turbines showed cracking which necessitated their being re-babbitted at the Westinghouse Company's shop. When these bearings were replaced, the original shim positions were slightly changed.

In March, 1939, the unit was opened due to a rub being heard while the machine was being taken off the line. It was found that the coupling on the main-turbine side of the stub shaft between the main and feed-heating turbines had broken. The collar of the thrust bearing for the main unit is located on this stub shaft. The breaking of the coupling made the thrust bearing ineffective for the main unit and the spindle moved so that the high-pressure dummies rubbed and seized. One broken blade was found in the tenth stage and three pieces of shroud bands were found missing in the same row. The fact that the rotating parts of the high-pressure seal were integral with the spindle necessitated a complete new spindle for this unit. There is a difference of opinion as to the cause of the breaking of the coupling and as to whether the coupling broke before the rub appeared in the high-pressure dummies. The author is of the opinion that the coupling broke first, as there had been a slight change in alignment when the re-babbitted bearings were installed.

The new spindle, with new blades, new dummies, and a new design of stub-shaft coupling, was installed in June, 1939, and the machine has run very satisfactorily since this change, with the one exception of the governor, which still has a hunting characteristic. This fact has necessitated the use of the load-limiting governor which has worked satisfactorily to date.

Until January, 1939, there was practically no evidence of blade fouling on either of the two high-pressure turbines. Beginning in January, 1939, there was a capacity loss on the General Electric No. 5 turbine from 42,000 kW to 36,000 kW, taking place gradually over a three-month period. The turbine was then taken off the line and allowed to cool for 12 hours, after which it was washed out with low-pressure steam from one of the boilers, without any water being admitted for de-superheating. This method of cleaning did not prove effective, and on March 20 the machine was again taken out after provision had been made to admit water with the steam. The washing lasted for a period of from 6 hours to 8 hours with a steam pressure of 15 lb. to 20 lb. per square inch, which was sufficient to turn the turbine. The steam temperature was 215 deg. to 220 deg. F. This method of cleaning proved satisfactory and the load on the turbine was increased to 42,000 kW. Ten days later the turbine again showed signs of fouling and it was again necessary to wash the turbine on June 10. After the third washing, the load was again brought back to 42,000 kW from 38,000 kW, to which it had dropped.

No. 4 Westinghouse unit showed no sign of fouling when it was opened in March. It was first thought that the fouling of No. 5 General Electric unit was caused by the eliminator screens in the 5A and 5B boilers being plugged, thus allowing the solids to go out with the steam. Checks showed that the carry-over was less than 0·3 part per million, which was as low as could be measured. A different method of blowing down the boilers has practically eliminated the fouling, which proved that it is necessary to wash out lower waterwall headers and mud drums while the boiler is off the line at intervals of not over two weeks.

On No. 4 unit there was a double-frequency vibration on the generator end which was caused by the two-pole field of the generator. This trouble was eliminated when the machine went back into service, as the field has been provided with slots to compensate for the lack of pull on the sides 90 deg. from the field coils. No vibration has been experienced on either of the high-pressure turbines.

There is a by-pass connection around the throttle valve of No. 4 unit which will pass a quantity of steam sufficient to keep the blades partially cool in case the throttle valve is closed and the generator is on the line operating as a motor. A steam gauge in the high-tension control room gives indication to the switchboard operator of loss of steam at the boilers and, in case a throttle valve trips and the load starts down on the unit, the operator will trip out the generator in either case when the load has dropped to 2,000 kW, thus protecting the turbine rotor against overheating.

The Westinghouse unit uses an average of 10 cub. ft. of hydrogen per day,* and the General Electric unit uses an average of 30 cub. ft. There has been no trouble due to the use of hydrogen in either machine. The hydrogen was not used in the Westinghouse generator until July, 1939. A load of 45,000 kW at 0·9 power factor could be carried on this generator using air as a cooling medium.

Both high-pressure units are started up integrally with the boilers; that is, as soon as there is a pressure of 200 lb. in one of the boilers, the turbine is gradually brought up to 200 r.p.m., where it is held for approximately 1 hour. The exhaust from the turbine is used in the station auxiliary steam line at 5 lb. back pressure. The pressure is then brought up and, when it reaches 600 lb., the exhaust steam is cut into the 200-lb. header. From this point, 1 hour is allowed to bring the machine up to full speed. In stopping the unit, no special precautions are taken, other than those used on any low-pressure unit, with the exception, however, that the machine is kept on the turning gear for a period of time varying from 24 hours to 48 hours when stopping the Westinghouse machine and 24 hours for the General Electric machine. There is a rise in the exhaust-casing temperature immediately after shut-down up to 670 deg. F. This temperature has caused no trouble to date.

High-Pressure Boilers.—Both sets of boilers for Nos. 4 and 5A units have operated successfully at 1,300 lb., and 450,000 lb. of steam output, but, to date, it has not been possible to operate at the rated load of 500,000 lb. per hour without dissociation of water due to hot tubes in the top boiler-header sections or excessive carry-over. Changes in baffle and washer designs in the drums have been made and it is expected that in a short time the guaranteed output will be obtained. Trouble with the refractory at the burner has been experienced and new carborundum blocks and refractory are now being tried. No trouble with slag-screen tubes has been experienced to date. The chrome ore over the slag-screen tubes has to be replaced every time the boiler comes off for cleaning.

The temperature of the steam is 900 deg. F. and is controlled with a flue-gas by-pass around the superheater. This control has worked satisfactorily and it has been possible to maintain the desired temperature over all ranges of load. The outlet temperature of the exhaust steam leaving the turbine governs the steam temperature entering the turbine as the low-pressure units now installed in Waterside Station are not built to use steam at a temperature much over 525 deg. F.

The ash composition and the fluid temperature have a great influence on the cleaning problems of the high-pressure boilers. Coal that has an initial ash-deformation temperature of not less than 2,200 deg. F. has been determined upon after 2 years of operation. At present, the cleaning of the boilers is done by hand, and by taking the boiler off the line for a few hours, about twice a week, thus allowing the slag formation on the tubes and side walls to cool and fall off. An experiment on the problem of cleaning the side walls of the high-pressure boilers by the use of a hand lance of special design, which has been used successfully at the East River Station for many years, is now being conducted. A nozzle to use water on the steam-generating tubes is also being made up for trial. Three men per watch of 8 hours each are continuously occupied in keeping slag off the boiler and superheater tubes. Soot blowers are used on the economiser tubes with good results.

Illuminating gas from the street mains is used in bringing the boilers up to pressure and also to ignite the pulverised fuel. A period of 5 hours to 6 hours is taken to bring the boiler up from cold. The gas is ignited by an electrical "glow bar" which is located directly in the path of the gas. The glow bars have burned out quite frequently, but as there are four burners per boiler, no trouble has been experienced with the ignition of the coal. The induced-draught fans are always in operation before the gas is turned on the boiler.

The performance of the mills has been uniformly good. They give a fineness of 80 per cent. through 200 mesh, 96 per cent. through 100 mesh, and 99 per cent. through 60 mesh. The mills run quietly, and very little trouble has been experienced other than the replacement of the mill rollers after their normal expected life. The average life of the rollers is 85,000 tons; scrapers, 18,000 tons; and bull rings 85,000

* This system has been in operation for only a very short time.

tons. Only two grades of coal have been used on these mills, namely, Coleman "Colver" and Weaver "Revloc." As these two are the only coals used, the data on the sensitivity are rather limited.

The flame stability has been satisfactory at all loads above one-third of the rated capacity of the boiler. A pulsation in the furnace has been experienced, the cause of which the boiler manufacturer is attempting to ascertain. A new primary fan inlet is being tried out as tests show that the initial pulsation starts at that point.

The Hall treatment is used in these boilers and consists of the following chemicals: An average of 86 lb. of disodium crystallised phosphate is used per 24-hour day for two boilers. An average of 21 lb. of sodium hydroxide is used per 24-hour day for two boilers. The phosphate is introduced directly in the boiler drum by means of high-pressure pumps, while the sodium hydroxide is added by gravity to the boiler feed between the de-aerator and the boiler-feed-pump suction. Samples of boiler water are taken three times per day and analysed for sodium hydroxide, sodium chloride, and sodium phosphate.

The boiler concentration is held at 450 parts to 500 parts per million, but it is thought that by the use of boiler-drum baffles, which have now been installed, the boiler concentration can be carried as high as 800 parts per million without excessive carry-over. Small amounts of scale were found in the boiler tubes, while the drum was free from scale, and very little deposit was found on the side-wall tubes.

There have been several cases where the lack of feedwater necessitated the shutting down of the high-pressure boilers. On two occasions, the side waterwall of one boiler ruptured, and as the feed lines for both boilers for one unit come off the same header, the pressure dropped, thereby necessitating the immediate removal of the other boiler from the line. Another shut-down of the boiler due to the loss of feedwater occurred when the automatic valve, controlling the feedwater level in the drum stuck, and the water tender, while endeavouring to put the valve on hand operation, jammed the valve in such a manner that the valve closed, and the boiler had to be taken off the line. No shut-downs due to loss of feedwater to the boiler feed pumps have occurred.

Four of the six boiler feed pumps now in use at Waterside are motor-driven; the remaining two being driven by steam turbines. The two steam-driveh pumps are so designed that they can be brought up to speed almost instantaneously. The motor-driven pumps are driven by constant-speed motors. The boiler feed pressure drop is taken across the boiler feed valve, there being no excess pressure valves used. The availability of the Worthington boiler feed pumps has been 97·6 per cent. There has been practically no maintenance on these pumps other than the normal packing of the glands.

One of the difficulties experienced with steam-driven pumps has been the leak-off valve from the outlet header to the suction header, which failed on several occasions. The trouble was caused by an excessive drop across the valve and this was finally overcome by putting two valves in series with a pipe made with labyrinth orifices in it, in order to help in building up a resistance to the water flowing through the valves. The pump manufacturers asked that the steam-driven boiler feed pump always be operated with the by-pass valve partly cracked so as to permit some water to pass through the pump at all times.

Air Heaters.—There has been no means of preventing condensation in the air preheaters during the starting up of boilers or while operating at light loads, and this has caused considerable fouling of the air preheaters with the consequent loss of boiler capacity until the air preheaters were cleaned or washed. Due to load conditions one of the four boilers had to be taken off every night. An experiment was tried using a movable air jet, which blew down from the air-inlet side of the air heater. The nozzle was so adjusted that it would move in and out so that all parts of the surface were blown every 2 hours or 3 hours. Compressed air at 125 lb. pressure was used for this blowing. Steam-jet soot blowers originally installed with the air preheaters operated partially satisfactorily. A by-pass around the air preheaters has been installed on Nos. 4A and 4B boilers, and, if it proves successful, a similar by-pass will be installed on Nos. 5A and 5B boilers.

The most successful method of cleaning air preheaters is by washing them with boiler feedwater which usually restores the draught drop through the air preheaters to its original figure.

Several times during the life of the boilers, it has been necessary to reduce the capacity of the boilers due to the lack of secondary air, because of the dirtiness of the air preheaters. When this condition occurs, it is necessary to take the boiler off the line at the earliest opportunity and wash the air preheaters.

De-aerators.—It has been found that, when the steam pressure in the de-aerator is kept above 2¼ lb., the de-aerator will give almost 100 per cent. de-aeration. If, however, the steam pressure is allowed to vary for any reason, there will be a certain amount of oxygen fed into the boiler. The steam to the de-aerator is controlled by a regulating valve at the feed-heating turbine. The operation of this valve has been investigated and it was found that there is an intermittent flow of steam from the feed-heating turbine to the de-aerator with this type of control. A new control valve will be installed at the de-aerator to insure sufficient steam at all times for complete de-aeration. The water flow to the de-aerator is controlled by a float valve which is actuated by the water level in the de-aerator. Some trouble has been experienced in maintaining the water level in No. 4 de-aerator, while no trouble has been experienced on No. 5. A new control valve, the same as on No. 5, will be installed at an early date.

The feedwater is de-aerated in the condensers of the low-pressure turbines before being sent to the de-aerators of the high-pressure units, but there is equipment through which some air may come in contact with the feedwater; such as leakage through the packing of the hot well pump, etc., which necessitates the use of a de-aerator.

The de-aeration of make-up water takes place in the condensers of the low-pressure units, and the make-up water comes over mixed with the condensate from the unit to which it was admitted. Since the installation of the high-pressure units in Waterside, it has not been possible, due to load conditions, to cut out the low-pressure boilers. The supply of all make-up water needed in the station is fed to the low-pressure boilers, so that the high-pressure boilers have 100 per cent. condensate.

On several occasions an idle high-pressure boiler was filled too fast and thereby drained the de-aerator to such a point that make-up had to be put into the de-aerator from the city water connection, thus adding to the work imposed upon the de-aerator, with a resulting decrease in de-aerator efficiency. The boiler operators are cautioned against filling the boilers too rapidly, and also against a too rapid heating of boiler tube and drum surfaces.

High-Pressure Heaters.—All of our heaters are of the vertical type with a floating head. The only trouble experienced with cleanliness of the tube has been that of oil coming from the exhaust steam, necessitating the washing of the tubes. Some trouble has been experienced due to leakage of the heads of the heaters. Due to the location of these heads in the boiler room, the work of removing leaking heads is difficult. There have been 43 tube failures in the No. 5 heaters and no tube failure in the No. 4 heaters. As two heaters are operated in parallel, it is possible to take one heater out of service to make the necessary repairs without excessive drop in feedwater temperature.

Station Performance.—During the period from September 10, 1937, to July 31, 1939, turbo-generator No. 4 generated 325,909,000 kWh, the maximum load carried being 47,000 kW and the availability factor 74·8. In the period from June 29, 1938, to July 31, 1939, turbo-generator No. 4 generated 258,260,000 kWh, with a maximum load carried of 52,000 kW. The availability factor was 94·2. During periods ending on July 31, 1939, but beginning at different dates, the high-pressure boilers had availability factors as follows:—Boiler No. 4A (commissioned September 10, 1937), 65·4; boiler No. 4B (commissioned September 10, 1937), 69·2; boiler No. 5A (commissioned June 29, 1938), 79·2; boiler No. 5B (commissioned July 25, 1938), 86·3.

(To be continued.)

PROGRESS OF HYDRO-ELECTRIC POWER IN CANADA IN 1939.

CONSIDERABLE activity was shown in Canada last year in the installation of new water-power plants and in the extension of transmission and distribution facilities in many parts of the Dominion. Moreover, increased production in the mining, pulp and paper, and many other industries, and a steady growth in the domestic load were reflected in a substantial expansion in the demand for power, it being stated by the Hon. T. A. Crerar, Minister of Mines and Resources of the Dominion, in his "Annual Review of Hydro-Electric Progress in Canada," that the production of electric energy established a new high record during 1939. This is indicated by the monthly figures of the output of central electric stations, compiled by the Dominion Bureau of Statistics, Ottawa; each month of 1939 showed an increase over the corresponding month of 1938 and, for the 10-month period January-October, 1939, an aggregate increase of more than 9 per cent. was recorded. Increased demand due to war activities had not been experienced to any material extent during this period, but it is thought that such activities will undoubtedly lead to substantially increased loads. It is pointed out, however, that with existing generating facilities and those being provided, the industry, in most areas, appears to be favourably situated to meet any additional demands.

The Review states that new water-power plants installed in 1939 aggregated 97,040 h.p., which, with an installation of 1,400 h.p. omitted from the Review for 1938, brings the total plant capacity for the Dominion, at the end of 1939, to 8,289,212 h.p. The greater part of the increase in installed capacity, amounting to 87,441 h.p., was made up of extensions to existing stations in Saskatchewan, Ontario and Quebec. New development included a 3,300-h.p. plant built by Messrs. The Consolidated Mining and Smelting Company, Limited, on the River Charlot, at Wellington Lake, Northern Saskatchewan; a 2,000-h.p. plant constructed by Messrs. Berens River Mines, Limited, on the Duck River in North-Western Ontario; a 1,500-h.p. plant built by Messrs. The Ontario Paper Company, Limited, on the Black River, near Heron Bay, in Northern Ontario, and smaller plants in other parts of Ontario and in Quebec and Nova Scotia. The extensions to existing stations in Saskatchewan, Ontario and Quebec, aggregating 87,441 h.p., included the addition of a fifth unit of 19,000 h.p., and the conversion to 16,500 h.p. of the three original 14,000-h.p. units at the Island Falls plant of Messrs. The Churchill River Power Company, Saskatchewan, the completion, by the Ontario Hydro-Electric Power Commission, of a 7,500-h.p. unit at the Ear Falls Station on the English River; and the bringing into operation of a ninth unit of 53,000 h.p. at the Beauharnois plant, on the St. Lawrence River, of Messrs. The Beauharnois Light, Heat and Power Company, Limited, Quebec.

Important works are in progress in British Columbia, Messrs. The West Kootenay Power and Light Company, Limited, having completed the removal of materials from the bed and sides of the Kootenay River at Grohman Narrows, near Nelson. This work was carried out in compliance with an Order of the International Joint Commission permitting the storage of water in Kootenay Lake. A total of 334,585 cub. yds. of gravel and boulders and of 17,297 cub. yds. of solid rock were removed. This will materially increase the flood capacity and improve the general situation on the Kootenay River. To utilise further the storage waters thus made available, Messrs. The West Kootenay Power and Light Company are carrying forward the extension of their hydro-electric station at Upper Bonnington, involving the installation of two new turbines, each of 25,000 h.p., together with two 20,500-kVA generators and other equipment. This work is expected to be completed this spring. In the Province of Quebec construction work on the St. Maurice River Plant, at La Tuque, of Messrs. The St. Maurice Power Corporation, has proceeded according to schedule. Out of a total estimated quantity of 250,000 cub. yd. of concrete in the permanent structures, 187,000 cub. yd. were placed during 1939. The installation of the first hydraulic turbine has been commenced and it is anticipated that the first unit of 40,500 h.p. will be ready for operation in August of the present year, and that the second, third and fourth units, which will complete the initial installation of 162,000 h.p., will be ready for service in December, 1940. The development work of the Quebec National Electricity Syndicate, on the Upper Ottawa River, progressed steadily during the summer and autumn of 1939. Earth and rock were excavated and concrete placed. The construction of a permanent road from Cadillac to the plant site and clearing work for the transmission line, from the plant site to Noranda, will be completed in the near future. The initial installation is to have an horse-power of 48,000, and the plant will work under a head of 70 ft.

While no new hydro-electric installations were undertaken in Manitoba, the Power Commission of that Province constructed 225 miles of transmission lines and brought electricity to twenty communities. The Commission now possesses 1,768 circuit miles of transmission lines and serves 138 communities. In Ontario, a number of extensions were made to the high-tension transmission facilities in the various systems of the Power Commission and approximately 2,700 miles of rural line were constructed during 1939. Investigations of new sources of power to meet future needs were also carried forward. The New Brunswick Electric Power Commission undertook no new hydro-electric development during the year and confined its constructional activities to short extensions, totalling 243 miles, to existing transmission lines. Extensions to transmission lines and new lines, totalling 308 miles, were constructed by the Nova Scotia Power Commission during 1939, while a further 80 miles of line were built by Messrs. The Avon River Power Company and Messrs. The Nova Scotia Light and Power Company. Messrs. The British Columbia Power Corporation, Limited, completed substantial enlargements of a number of their substations and extensions of distribution circuits in their Vancouver Island and mainland systems.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

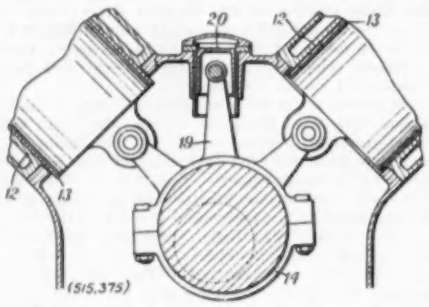
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

INTERNAL-COMBUSTION ENGINES.

515,375. Sleeve-Valve Engine. F. H. Stark, of Chellaston, Derby. (4 *Figs.*) May 30, 1938.—Two cylinders 12 of the Vee-type sleeve-valve engine are served by a common crank. The sleeve-valve operating gear consists of a sheave 14 mounted on an eccentric adjacent the crank-web, the sheave having two rigid arms connected directly to the sleeves 13 through universal joints at the



lower ends of the sleeves. The sheave also has a third rigid arm 19, which is connected to a piston 20 reciprocating in a cylinder. The piston constitutes a crosshead, which is reciprocated as the eccentric rotates, and due to the angular movement of the arm 19, the sheave 14 is rocked backwards and forwards. This rocking movement imparts a rotation to the sleeves 13 in addition to the axial movement imparted by the throw of the eccentric. Since the piston 20 is arranged symmetrically between the cylinders similar movements are imparted to each of the valves. A slightly different arrangement is adopted for X-type engines. (*Accepted December* 4, 1939.)

PUMPS.

515,124. Pump Cooler. W. H. Allen, Sons and Company, Limited, of Bedford, and A. Maude, of Bedford. (3 *Figs.*) May 24, 1938.—The apparatus utilises the flow of water through a centrifugal pump to cool another

Fig.1.

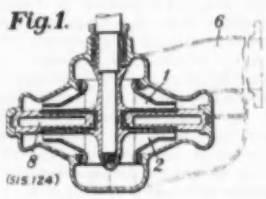
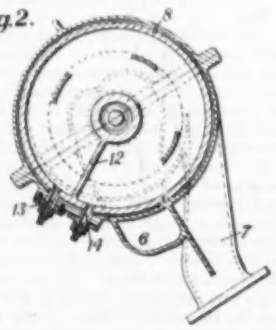


Fig.2.



fluid. A two-stage centrifugal pump of the vertical shaft type for marine work has the two impellers 1, 2 mounted back to back on the shaft at a sufficient distance apart to accommodate the cooler element between them. The suction is at 6 and the discharge at 7. The two impeller chambers are separated by a hollow annular drum 8 which constitutes the cooler. The drum 8 is shouldered into the pump casing so that it is held in position when the halves of the casing are bolted together. The central hole of the drum accommodates the shaft and the contiguous hubs of the impellers, and when the pump is assembled the drum is completely enclosed in the casing. The interior of the drum is divided by a radial partition 12 between the outer and the inner walls, and on each side of the partition, pipe connections 13 and 14 pass through the wall of the pump casing and are connected to circulating pipes which supply and take away the fluid to be cooled. The diameter of the drum is somewhat greater than that of the impellers, and the side walls are thickened towards the periphery so that they form one side of each of the annular discharge chambers of the pump.—(*Accepted November* 27, 1939.)

STEAM ENGINES, BOILERS, ETC.

514,852. Underfeed Stoker. International Combustion, Limited, of London, and R. W. Edwards, of London. (3 *Figs.*) May 17, 1938.—The invention aims at overcoming the disadvantages of uneven distribution of the fuel at the sides of the furnace, degradation of the fuel, and the segregation of coarse and fine grades. The end of the screw 1 is housed in a hopper 2 on the outside of a wall of a retort. On an extension of the screw 1 is fixed a ratchet wheel 3 and on each side of the ratchet-wheel pawl-carriers 4, 5, are pivoted. The screw extension is carried through a wall 7 of the housing and through a

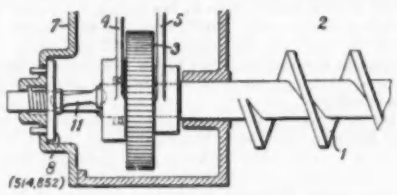
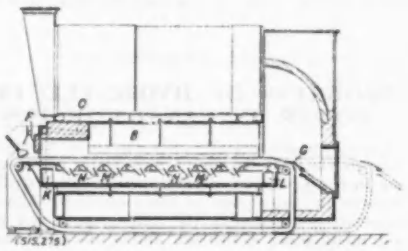


plate 8 which is prevented from rotating by guide pins. A spring biases the plate 8 towards the ratchets, while links 11 are mounted in sockets in the plate 8 and pawl-carrier 4. If the hopper 2 contains coal and the screw 1 is rotated anti-clockwise by the pawls, the reaction between the coal and the thread on the screw causes the screw to move to the left. As a result of oscillation of the pawl-carriers, the links 11 will take up an oblique position and allow the screw to move to the left about $\frac{3}{8}$ in. to 1 in. As the pawl-carriers are returned to their original position, the links 11 move more or less parallel to the screw and displace it to the right. This movement is non-rotary and causes the screw to carry the coal towards the retort. The pawl-carriers are oscillated by a continuously rotated crank arm. The screw is thus alternately rotated and advanced axially without rotation.—(*Accepted November* 20, 1939.)

515,275. Steam-Generator Grate. Bennis Combustion Limited, of Bolton, and A. W. Bennis, of Bolton. (2 *Figs.*) May 28, 1938.—The invention is a chain grate for mounting in a boiler flue and is suitable for burning any class of fuel. The upper run of the travelling grate passes through the flue B and downwards at the rear end through the casing, while the lower run passes underneath the boiler shell and up over a driving drum at the front end. Immediately behind the hopper is a door F which can be raised and lowered. This door is carried close up to the rear of the hopper and regulates the depth of fuel fed on to the grate. At the rear end of the grate



is a dumping plate G for collecting the clinker and delivering it on to an inclined surface which leads down to an opening in the rear wall of the boiler casing. The air space between the underside of the grate and the bottom of the flue B is enclosed in a casing which extends right through the flue, projecting a short distance at both ends, and is supplied with forced draught at the front and rear ends by air ducts K and L. With this arrangement, more air can be supplied for combustion or air at a lower pressure can be used. Hoppers M are mounted in the flue on the underside of the grate, each with an adjustable damper N so that the supply of air to any part of the grate can be controlled. Additional air is supplied above the grate at the front end of the boiler by air ducts O in the casing at the front end of the flue and these are connected to the duct K. The ash which is collected beneath the hoppers M in the flue, or in the casing beneath the grate, can be removed by reversing the draught in one of the air ducts supplying air to the underside of the grate and the ash will then be blown out, a door being provided for this purpose. The grate is of considerably larger area than hitherto provided in this type of boiler, and is suitable for burning anthracite and low-volatile fuel.—(*Accepted November* 30, 1939.)

MISCELLANEOUS.

514,478. Endless-Band Conveyor. Baker Perkins Limited, and J. C. Paterson, of Peterborough. (5 *Figs.*) April 7, 1938.—The invention is an endless-band biscuit conveyor which turns through 180 deg. It consists of a frame which supports a vertical stub shaft 7 on which are pivoted a pair of discs 8, 9 with inturned rims (Fig. 1.). On either side of the discs 8 and 9 is a pair of coned terminal rollers 17, 18, forming nosings around which the conveyor band turns as it travels from the upper to the lower lap. The roller shafts are supported at their inner ends by an inner frame 15 between the discs, the shafts passing between the rims of the discs. At either

Fig.1.

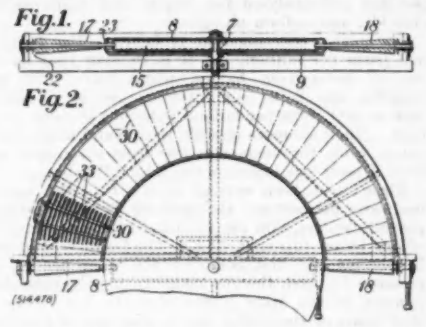


Fig.2.

end of the roller shafts are sprocket wheels 22, 23, for driving chains which form the margins of the conveyor belt. The chains are supported upon curved tracks which are auxiliary to main supporting tracks on the inside of the chain tracks. Between the chains is a series of radial bars 30, the ends of which carry supporting rollers running on the main supporting tracks. The spaces between the bars are filled by tightly-wound springs 33 under slight tension. To give a relatively smooth surface, covering flaps of canvas are clipped on one edge to a radial bar, being free at the other edges. The tendency for the surface to move towards the centre is checked by the abutment of the inner chain with the disc rims, the discs being free to revolve by the friction of the chain.—(*Accepted November* 9, 1939.)

514,497. Hot-Coke Quenching Car. James Buchanan and Son (Liverpool) Limited, and A. H. Humphrys, of Liverpool. (5 *Figs.*) May 7, 1938.—The invention is a floor construction for preventing water used for coke quenching from draining on to the undercarriage and machinery of the car. The sloping floor of the car consists of cast-iron plates supported on inclined transverse rails 15 which, in turn, are supported on longitudinal girders 16,

Fig.1.

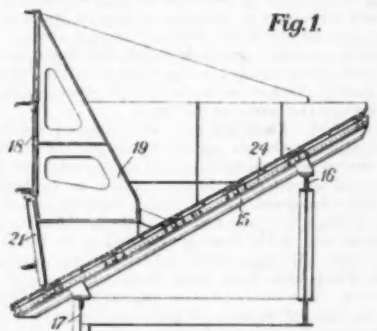
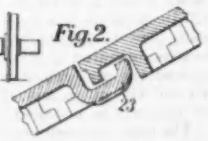


Fig.2.



17 forming part of the undercarriage. At intervals, along one side wall 18, are bracing members 19, the base of this wall having doors 21. The upper edges of the plates have depending lips 23 which underlie the lower edges of adjacent plates and constitute ducts which merge into sloping gutters 24. The plates are bolted to lugs on the gutters which, in turn, are bolted to the rails 15. The gutters discharge the quenching water, which percolates through the coke, clear of the undercarriage which is thus protected from rusting.—(*Accepted November* 9, 1939.)